FOOD AND THE
PRINCIPLES OF DIETETICS

Extract from 'Greek Byways,' by T R Glover

The day will yet come when the progress of research through long ages will reveal to sight the mysteries of nature that now are concealed A single lifetime though it were wholly devoted to the study of the sky does not suffice for the investigation of problems of such complexity It must take long successive ages to unfold all The day will yet come when our descendants will be amazed that we remained ignorant of things that will to them seem so plain Veniet tempus quo posteri nostri tam aperta nos nescisse mirentur

SENECA *Nat Quaest* VII 25 2

HUTCHISON'S

FOOD AND THE PRINCIPLES OF DIETETICS

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PREFACE TO THE TENTH EDITION

Although some measure of peace will have been attained by the time this edition appears its preparation was so overshadowed by war and the aftermath of war that the picture which we present cannot have the balance and perspective we should wish Almost the whole of Part I, Diet in Normal Life, is new, for the energy problem had to be restated in view of the extreme variability of the individual, the minimal protein intake to be reviewed in the light of evidence from the experimental use of isotopes, work upon the factors influencing calcium uptake and the effect of trace elements included and the section on vitamins thoroughly revised and especial reference made to the "refection" of the B group and the practical applications of that knowledge Two new brief chapters on the processing and hygiene of food have been incorporated into this part

Part II The Nature of Foods has been further compressed and also rearranged to give a somewhat more logical order of treatment Part III, The Principles of Feeding in Infancy and Childhood for which Dr C J Harris is responsible has been almost entirely rewritten Part IV, Diet in Treatment of Disease has been much modified and expanded For example the sections on obesity, diseases of the liver rickets and scurvy have been revised and largely rewritten The fallacies and dangers of the Hay diet have been fully set out and a new section on phosphaturia included The various solutions for intravenous feeding have been described including the new treatment with amino-acids The list of proprietary preparations of vitamins has again been revised

We very much regret that despite compression the book runs to 70 extra pages but the science of nutrition has grown is growing and should be encouraged to grow We have had to make a compromise *between a minimal diet and a plethora We hope that* our choice may commend itself

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shall have done anything to contribute to the reconstruction of the health and well being of this country when victory and peace are happily attained we shall feel abundantly rewarded

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TABLE OF EQUIVALENTS

In a book on dietetics it is difficult to avoid the use of several different standards of measurement. Thus the Metric System is usually employed in the scientific analyses of foods, and the Imperial System in the measurement of foodstuffs as purchased in this country, whilst even such rough domestic standards as spoons and cups must sometimes be referred to. The following table of equivalents of the different standards may therefore be found of use:

1 gramme	=	15.4 grains	
1 kilogramme	=	2 pounds 3¼ ounces	
100 grammes	=	3½ ounces (approx.)	

1 ounce	=	28.3 grammes	
1 pound	=	453.5 "	
1 fluid ounce	=	28.4 c.c.	
1 pint	=	568 "	

1 pint	=	20 fluid ounces	
1 tumblerful	=	5–6 "	
1 breakfastcupful	=	8 "	
1 teacupful	=	4 "	(approx.)
1 claret glassful	=	4 "	
1 sherry glassful	=	2 "	
1 tablespoonful	=	one half fluid ounce	

INTRODUCTION

THE HISTORY OF DIETETICS[1]

Dietetics is really a very young branch of science; it was not indeed until the middle of the last century that it could fairly be described as a science at all. This, it need hardly be said, was inevitable, for diet could not be studied satisfactorily until organic chemistry and the physiology of nutrition had made considerable advances. Even down to the beginning of last century the very word 'diet' was not always used in its modern acceptation, but still generally included a consideration of all of what used to be termed the 'non naturals'" (air, aliment, exercise and rest, the passions and affections of the mind, wakefulness and sleep, repletion and evacuation). Thus Willich, writing as late as the year 1800, defined dietetics as "a systematic view of all objects relative to health in general and to food and drink in particular"; it embodied, in short, everything that was known as to physical and mental hygiene and the promotion of individual health. This use of the term must always be borne in mind when studying the earlier history of the subject.

It was natural, of course, that some attention should have been given to the feeding of the sick so soon as anything like a systematic study of disease had begun, and we find indications of this in the Scriptures and, as far as the Egyptians were concerned, in the writings of Herodotus, while Pythagoras, the founder of vegetarianism, flourished as long ago as the sixth century B.C. It was with the dawn of Greek medicine, however, that the first faint beginnings of dietetics, as we now understand the term, may be discerned; but in no sense could Greek dietetics be described as scientific. It was not based even upon the result of observation, but was distorted by a false pathology and by unintelligible and semi-metaphysical hypotheses. We can see this if we glance at the writings of Hippocrates, Celsus and Galen—the three great Masters of Ancient Medicine. Hippocrates (460–377 B.C.), in his *Treatise on Ancient*

[1] An article first published by Sir Robert Hutchison in *The Practitioner*, January 1934, and reproduced here by permission of the Editor of that Journal.

fatter and scaly varieties Certain kinds of vegetables produce evil humours for instance, nasturtium, mustard and garlic beget reddish bile Lentils, cabbage, and the meat of old goats or beeves produce black bile Pork, lamb, purslain, and attriplex beget phlegm Heavy foods produce phlegm and black bile, and either of these is evil' We can here see the distorting influence of the humoral doctrines in full operation

Perhaps the best known, however, of mediæval writings is the *Regimen Sanitatis*, produced at the famous school of Salerno about the year 1100 It was a popular treatise on health in general, written in rhyme We may quote two verses dealing with diet [1]

> Doctors should thus their patients food revise—
> *What* is it? *When* the meal? and what its *size*?
> How *often*? *Where*? lest by some sad mistake
> Ill sorted things should meet and trouble make
>
> We hold that men on no account should vary
> Their daily diet until necessary
> For as Hippocrates doth truly show,
> Diseases sad from all such changes flow
> A stated diet as it is well known
> Of physic is the strongest cornerstone—
> By means of which if you can nought impart,
> Relief or cure vain is your Healing Art

The *Rosa Anglica*, written by John of Gaddesden (?1280–1361) about the year 1314 was intended for medical readers in the first instance, but was apparently largely borrowed from the *Regimen Sanitatis* It gives a good idea of fourteenth-century medicine but shows little advance on the views of Hippocrates Here is a sample of his dietetic teaching "Some eat more of fruit than of other food, wherein they do not well, for all fruits make watery useless blood, and prone to putrefaction—— On the whole it is best to do without fruit altogether"

Andrew Boorde (1490?–1549) wrote his well known book, *A Compendyous Regyment, or A Dyetary of Helth*, about 1542 a century after the close of the Dark Ages It is a popular work and deals with the general management of health but has many chapters on the different classes of foods, and others on the diet for different kinds of diseases His statements about foods are often rather arbitrary and, of course, coloured by the prevailing humoral pathology of his day Here are some extracts 'Bread having too much bran in it is not laudable" "Barley doth breed cold humours' Butter is made of crayme and is moyste of opera

[1] Walsh J J (1920) *Mediæval Medicine* London 53

tion" "Al maner of fysshe is cold of nature and doth ingender fleume" "Hares flesh is dry and doth ingender melancholy humors" "Peason and beanes repletyth a man with Ventosyte" "Milk is not good for them the which have gurgulacyons in the bely"

About a century after Boorde's *Dyetary of Helth* two notable books on the subject were published in this country [1] *Klinike or the Diet of the Diseased*, by Dr James Hart of Northampton, appeared in 1633, and the other *Via Recta ad Vitam longam* by Dr Tobias Venner (1577-1660) of Bath, was first published in 1620 the last edition appearing in 1660 The latter is perhaps the better known though Hart's is really the more interesting and important, but both writers use the word diet to cover general rules of health *Klinike* is a handsome folio and is written in a delightful style recalling often that of Burton's *Anatomy of Melancholy* which had appeared a decade earlier It contains short descriptions of the foods then in use and of their qualities, but is largely compiled from the writings of Galen, Dioscorides, and other classical authorities This passage is characteristic

Marjoram is a sweet pleasant and well-smelling herb hot and dry in operation It comforteth all the noble parts especially the stomacke, and may with good successe be used to further concoction comfort the stomacke and discusse wind It much comforteth the braine also and is good against all cold diseases of the braine and nervous parts

There are some satirical touches as when, in speaking of potatoes (then recently introduced into England) the writer says That outlandish root brought with us from the West Indies called commonly Potato, and by some Batato is of the same nature and property as the Skirret root or at least goeth a little beyond it but this pre-eminence it hath that it is, according to the common proverb Farre fetcht and deare bought and therefore good for Ladies' There is also a chapter, unique perhaps in the literature of the subject, entitled "Of strange and uncouth [sic] Diet, which

[1] Mention should also be made of a book by THOMAS MOFFET (? 1540-1604) entitled *Health's Improvement or Rules Comprising and discovering the Nature Method and Manner of Preparing all Sorts of Food Used in this Nation* which must have been written towards the end of the sixteenth century although it was not published until 1655 fifty years after the author's death A revised edition with an Introduction by Dr Robert James and a biographical account of Dr Moffet appeared in 1746 *Health's Improvement* is much on the same lines as the books of Hart and Tobias Venner and contains a general classification and description of foods and their properties as then understood

some people have in ordinarie use, as of Dogges Cats, Horses, Mules, Asses, Rats, Locusts, Frogges, Snailes and Man flesh "

The *Via Recta*, neither so elaborate nor so well written as *Κλιική*, had greater popularity The first part deals with the 'Nature and choice of Habitable places" and then there follows an interesting section on 'Bread" in which the great brown bread controversy is already foreshadowed In a chapter on the "Divers kinds of Drinks," the author speaks eloquently in praise of wine

Many and singular are the commodities of Wine for it is of it selfe the most pleasant liquor of all other, and was made from the beginning to exhilarate the heart of man It is a great increaser of the vitall spirits and a wonderfull restoror of all concoction, distribution and nutrition mightily strengtheneth the naturall heat openeth obstructions discusseth windinesse taketh away sadnesse and other hurts of melancholy induceth boldnesse and pleasant behaviour, sharpeneth the wit abundantly reviveth feeble spirits excellently amendeth the coldnesse of old age and correcteth the tetrick qualities which that age is subject unto and to speak all in a word it maketh a man more coragious and lively both in mind and body'

He adds the comfortable advice that wine should be given "with a liberall hand to men in the later part of old age—from sixty yeeres upward' He discusses also whether it would be expedient for health to be drunk with wine once or twice a month" and concludes not but thought it good for those who are 'wearied with great cares and labours' to drink sometimes 'until they be merry and pleasant but not drunken" He next considers foods in detail A few examples will show the nature of his teaching and how full it is of dogmatic statements and how entirely based, like that of his predecessors upon the humoral doctrines

'Bisket bread is only profitable for the phlegmatick and them that have crude and moist stomacks and that desire to grow lean because it is a great drier and therefore let such as are cholerick and melancholick beware how they use it

'Eels are very hurtful to those with gout dropsy or stone

Lampreys increase melancholy and are hurtfull to those with weak sinews

Mullet breedeth grosse and excrementall humors

Beanes are cold and hot in the first degree

Chestnuts are hot in the first degree and dry in the second

The chapter "Of the Manner and Customs of Diet" contains however, much sound general advice, e g

The dining room must not be bloomy hot for that may

soone occasion faintness and swouning by weakning the naturall heat and extracting the spirits

To feed upon more than foure dishes even at a great meale is somewhat immodest and excessive '

Three things he thought, were necessary at meals, an easy mind, thorough chewing and "not to reside in the chair of intemperance"

After the *Via Recta* no important book on dietetics appeared in this country for another hundred years, when Dr John Arbuthnot, the well known physician of Queen Anne's reign, published his essay "Concerning the Nature of Aliments and the Choice of them" in 1732 It is a popular work, for he remarks in his preface "I do not presume to instruct the Gentlemen of my own Profession" and it is written in the form of a number of dogmatic propositions, for example

Honey is the most elaborate Production of the Vegetable kind being a most exquisite soap resolvent of the Bile Balsamick and Pectoral '

Acrimony and tenacity are the two qualities in what we take inwardly most to be avoided '

The constituent parts of animals are (1) earth (2) a peculiar spirit analogous to that of plants (3) water (4) salts (5) oil '

The fruits of most vegetables are soaps; all soaps (which are a mixture of salt and oil) are attenuating and deobstruent resolving viscid substances

In a later edition he said that part of his treatise had been censured as obscure and unpractical—as well it might be—and indeed the whole book shows little advance upon Andrew Boorde or for the matter of that, upon Hippocrates The contributions of the eighteenth century to the science of dietetics were indeed negligible notwithstanding the fact that it was in this century that the curative effect of fruit and green vegetables in scurvy was first clearly recognized but that came about through the practical observations of the great voyagers such as Captain Cook and not through the labours of scientists Grateful mention must be made however of the work of William Stark (1740–70), who was one of the first experimental dietitians in this country, although his well meant experiments conducted upon himself tended probably to shorten his life (he died at the age of 29) rather than to add to knowledge

How little dietetics had even been influenced by the advance of chemistry especially in France throughout the century, is shown by Willich's *Lectures on Diet and Regimen* (1800) for he describes fat as 'the cellular substance of animal jelly' and salt as 'an excellent solvent of fat Nor had he entirely shaken off

ment as a part of curative medicine. The same distinction is in evidence in the United States for McCollum and his colleagues call their book *The Newer Knowledge of Nutrition*—not of Dietetics. Nutrition therefore means the study of food and drink in all its aspects; dietetics is coming to mean the use of this study in curative medicine. That is not the meaning the authors give to the word in this book; they use it in the sense that Sir Robert Hutchison gave it—they can hardly alter the book's original title—viz. the study of food in its relation to human need. In this book the practical aspects of nutrition will always be allowed to outweigh the severely scientific. Thus the authors are not so much interested in the chemistry and distribution of some recondite vitamin as in the practical difference to living which that knowledge might make.

The applications of our knowledge of nutrition are numerous and far reaching. They touch not only the care of the sick but the feeding of the well. They concern public health at most points—no health authority should be without its dietitian. Community feeding, whether in schools or factory canteens, needs dietetic supervision. Educational authorities cannot afford to be without advisors trained in dietetics. This subject runs in closest contact with agriculture, and therefore with politics, alas. It should have, and will have in any stable future, a great influence upon world politics.[1] In fact each year opens up new horizons in dietetics.

But while we welcome this expansion of the influence and applications of dietetics we have sundry warnings and reservations to make, and the rest of this chapter will be concerned with these. Most of us have recollections or knowledge of what happens in a gold rush. Much the same happens in any new territory opened up by science. Adventurers, good, bad and indifferent, rush in, and the ore they bring back is often anything but auriferous. Great caution is advised in accepting glitter as authentic fact. Further—to change the metaphor—the subject of dietetics is *developing so rapidly that change of perspective alters the relative* size and importance of a discovery. Old dogmas disappear. New ones, alas, arise. In fact, to quote Stefansson, the Arctic explorer:

Unless it be religion there is no field of human thought where sentiment and prejudice take the place of sound knowledge and logical thinking so completely as in dietetics.[2]

Now dogmas have no place in science. In fact the main duty of a scientific man is to do his utmost to pick holes in his most

[1] ORR (1943) *Food and the People*. The Pilot Press, London.
[2] STEFÁNSSON (1921) *The Friendly Arctic*, 191.

cherished beliefs This is essential for the dietitian, if he wishes the study he has taken up to become a science, still more an "exact science"

In the section on the History of Dietetics with which this book opens, there is a statement that needs some definition and qualification It is "The effect of this work on dietetics [the work of Carl von Voit and his school] was immediate and it is from this time that it [dietetics] can fairly claim to be regarded as an exact science Most good work in dietetics springs from Voit for he was the first to apply the exact and elaborate methods of physics and chemistry to the study of nutrition but Voit himself would have been the first to deny that the exactitude which physics can employ in weighing a non living substance or chemistry in estimating the atomic weight of an element can be achieved in the science of nutrition Why the very weight of a 2-kilogramme Belgian hare changes by several decigrammes during the process of weighing as one of us saw in Voit's own laboratory How much more difficult then must it be to weigh a man with an accuracy of 1 in 20 000 Such an accuracy is, of course far beyond what is ever claimed in dietetics but it must be recognized that when an argument or theory is based on the fluctuation in weight by a few grammes an error of 1 in 20 000 in a 70-kilogramme man's weight may involve a final error of 1 in 10 or even 1 in 1 !

Because the layman has such exaggerated views of the capabilities of the dietitian and the exactitude of dietetics it is perhaps worth while thus early in the book to set out its limitations and the factors which prevent its ever becoming so exact a science as physics or chemistry

We are met at the outset with the difficulty of definition This, however is not surprising Is it not said that the physicist Tait had some twenty definitions of matter in his famous text book of physics and that the best of them was "that which is a permanent possibility of sensation"? Our definitions of "food" and "dietetics" will be almost as unsatisfactory Voit in Hermann's *Handbuch der Physiologie* defines food as a 'palatable mixture of food stuffs which is capable of maintaining the body in an equilibrium of substance or capable of bringing it to a desired condition of substance The reader will note the intrusion of the word 'palatable' which introduces into the definition a whole range of imponderables from the realms of psychology Is a food less a food when it is not palatable? Is cod liver oil not a food because it was unpalatable to most Victorians and Edwardians? And is it a food only to the neo Georgians who have been brought up to take it from their first month of life? Is it "not a food"

when it is concentrated, and a food when it forms an ingredient of ■ palatable fish sauce or savoury?

If we want dietetics to be an exact science it must dispense with *psychological considerations*[1] *or at least delimit their relations to* and intrusions into dietetics We offer the following definition of food anything which when absorbed into the body via the alimentary tract, is capable of doing one or more of three things, (i) furnishing the body with material from which to produce heat, work, or other forms of energy (ii) enabling it to grow or to repair its wear and tear and (iii) supplying regulators of its functions of growth, repair, and production of energy Thus milk ■ usually called ■ food, and is to the dietitians the food *par excellence* It can be used to supply energy in the form of heat and work The combustion of the materials of 1 pint of milk in the cells of the body would *yield energy equivalent to 378 kilocalories It promotes* growth in the body and repair Milk also contains some thiamine, some riboflavine some nicotinic acid or possibly nicotinamide, much vitamin A a little ascorbic acid and, in summer vitamin D All these substances are catalytically concerned in the production of energy in the cell and, without them, it must die On all three counts milk is to be considered a food Other foods, e g the lemon will come into consideration practically on the third count only Its contribution to body building is infinitesimal to production of energy, negligible only because of its marked power *of supplying vitamin C is it included in the category of a food*

Our definition is as unsatisfactory as all definitions of fundamental ideas are, but at least it is less open to criticism than those which have preceded it[2] It is difficult to exclude substances which can be metabolized when injected under the skin or into the blood and yet they are excluded by the above definition which none the less permits the inclusion of drugs It brings into prominence, however the three main functions of food Food provides the materials for growth and repair of the fabric of the body It supplies materials which can be oxidized in the body with the

[1] RENNER (1944) in *The Origin of Food Habits* Faber & Faber London protests against this exclusion of psychology from dietetics much as Ruskin years ago exclaimed against its exclusion from economics possibly with similar justification We shall deal with this later

[2] To show how difficult it is to devise an adequate definition let us take the examples of tea coffee cocoa and meat extracts In common parlance they are foods But to the biochemist tea and coffee are almost certainly not foods whereas cocoa certainly is Meat extracts creep in on the score of their nicotinic acid All come into the net of our definition

result that the energy set free by oxidation may be used in performing work and in producing heat It also supplies the body with substances (catalysts, food hormones vitamins) which control, though present in almost inconceivably minute amounts the various processes of the body Food is responsible for the conservation of the material of the body, for the maintenance of its output of energy and for the regulation of these functions

We need not worry, however about the logical unsatisfactoriness of our definition of food, except perhaps when dealing with the layman But tell me, Doctor,' he says, "are not turnips good food? Have not onions a high food value?" We cannot answer his questions until we discover whether he means by food what a dietitian means, whether he is aware that food has a threefold function and which of the functions if any, he has in mind

At this point it may be well to inveigh against the vague terms which have invaded popular and not so popular dietetics Dietetics can never become an exact science while such terms as 'food value" "balanced diet" "nourishment' 'malnutrition,' etc, go undefined. If food value' is used of a food to mean its quantitative yield in body building material in energy value or in vitamins the term is a useful one, but if, as is usual, it means 'this food is, or is not commonly used by people' it is useless—in dietetics "Balanced diet" may have a meaning to the dietitian, though how one can pretend in the present state of our knowledge that there is a right and proper equilibrium between protein fats, carbohydrates the six or ten essential metallic and non metallic elements and the six, seven, or more vitamins and that we know that balance passes comprehension Probably the term means, if used by the scientific dietitian, a diet in which no particular one of the groups of substances enumerated in the preceding sentence is in defect or excess Thus if there are no carbohydrates or only 5 milligrammes of iron per day, or 300 milligrammes of calcium, or 100 international units of vitamin B_1 (thiamine) or 20 or 20 000 international units of vitamin D we might justifiably say that the diet is unbalanced If the term "balanced diet' means no more than a good all round diet then we can have little quarrel with it But it has an air of exact science and is used by the charlatan to deceive the layman and even the elect It is significant that a search for such vague terms, with the unfortunate exception of "malnutrition" shows that they are not used in modern text books of dietetics They can be utilized as a danger signal, warning one of charlatanry much as the spelling of protein as "proteid' and the use of 'albuminoid' stamps a book on dietetics as being out of date

A definition of dietetics is that it is the science of applying the hitherto discovered facts about food and its use in the body to the feeding of the individual, the family, and the nations There is no finality about dietetics, for though much has been discovered about food, much remains to be discovered Until about 1900 all the emphasis in dietetics fell upon Calories It then shifted to the proteins Thence to the vitamins and the mineral elements To day we say with Sherman that dietetics stands foursquare upon Calories, proteins mineral elements, and vitamins, and it is only with an effort that we can imagine that there may be still more legs for dietetics to stand upon Instead of being a quadruped it may become even an octopod or a centipede Who knows? That it is altering in detail is seen from the dethronement of spinach as a source of calcium and iron to the body The whole of the calcium (595 milligrammes per 100 grammes) in spinach may be sterilized by the oxalate present and it has been shown that tomatoes with only ⅛th of the iron of spinach yield more iron to the body Pediatricians accustomed to give sieved spinach for iron to a baby *six months old must revise their training And as dietetics alters* in detail so may it alter in gross We dare not, as dietitians, dogmatically claim any finality in the subject One dogma after another is discarded (e g the danger to kidneys of a high protein diet when the blood urea is within normal limits the need for a low Calorie diet in fever, the value of roughage in all types of con stipation) as sound reasoning and experimentation take the place of prejudice and custom We must approach the science sceptically and with a readiness to throw overboard our most cherished dietetic beliefs Dogmatism about food is an excellent danger signal of the presence of ignorance and charlatanism

Probably the feeding of the individual as compared with that of the family and the nation claims most attention in dietetics partly because dietetics unfortunately in this country is used more in treatment of ill health than in preservation of health and partly because we are all egoists and more concerned with our own bodies than with those even of our children The Victorian parent regularly sent and the rich parent frequently to day sends his offspring to boarding schools where the diet was and sometimes still is such as he would not give to his servants (Things in that respect, however, are improving and even the most famous public schools are beginning to consult the dietitian)

In one way attention to individual diets is an advantage A child, whatever its age, should be considered as an individual and not lumped in with the rest of the family The custom has grown up in dietetic work in Great Britain of considering the family as a

whole, in which a child of, say 5 years of age counts as some fraction of an adult male for all his needs That plan should be abandoned A pregnant woman is not a non pregnant woman multiplied by some factor dietetically she is a different individual altogether A child of 5 may need more calcium than an adult and a boy of 14 certainly does Consequently though the family is the catering unit in this nation and is likely to remain so the family considered dietetically consists of a number of units each with its own individual wants as regards proteins Calories mineral elements, and vitamins

This again applies to the nation You have not solved the problem of the feeding of the nation when you have supplied let us say sufficient Calories and protein, though you will have gone a long way in that direction You have not solved it till every individual has had a sufficiency of all the desiderata in diet—proteins Calories mineral elements and vitamins—has had in fact an optimum diet i e one which gives no improvement in health and growth when any of its constituents is increased or reduced in amount How far we are in Great Britain—indeed in the world—from that position will be seen in the sequel though it must be said emphatically that there is no reason save gross ignorance sloth and a touch of poverty, why we should not, at any rate in this country, be properly fed. It is the function of the dietitian to see that we all are properly fed There are three types of dietitians apart from other people engaged in nutritional work They are

(i) *The Hospital Dietitian* whose work is in the wards and out-patient departments of hospitals adjusting the protein Calorie mineral elements and vitamins of a diet to the needs of patients and demonstrating and explaining to patients how to carry out in the home the preparation of diets given in hospital

(ii) *Dietitian caterer* whose work consists of large scale catering in institutions such as boarding schools hospitals infirmaries school and factory canteens In the past and for the most part in the present this work has been carried out by caterers with no dietetic training

These two classes of dietitians have been and will be naturally recruited from among nurses and graduates of colleges of domestic science There is a great and growing demand for caterer dietitians

(iii) *Public Health Dietitians* Attached to the Ministries of Food, Health Education and Agriculture and to the local authorities in Health and Education there should be, and in a few cases already are dietitians trained in the science of nutrition to a research standard whose duty should be to advise those Ministries and local

authorities concerning the nutrition, present and future, of the People The Hot Springs Conference of the United Nations, 1943, definitely recommended that all public authorities should have such an adviser attached and that his training should be in the highest degree scientific and of a research nature The recruits for this type of work are those with University degrees in science—particularly physiology and chemistry During the war of 1939–45 the Ministries of Food and Health secured the help of several such dietitians and doubtless in the future this class of dietitian will be increasingly needed and utilized

There are two main reasons why dietetics as applied to the individual, the family, and the nation suffers from a condition of inexactitude The first is the varying composition of food or even of its individual parts No one piece of bread has the same analysis as any other piece The red side of a strawberry has more ascorbic acid in it than the white side The outer leaves of a cabbage have more calcium and pro vitamin A than the inside leaves Consequently unless we analyse a sample of what is being eaten by the person investigated we cannot be sure what he is actually getting Thus the number of Calories obtainable from a pound of white bread varies from 1037 [1] to over 1200 [2] in other words the error of taking one figure rather than the other is about 15 per cent In the daily diet of a working class man the difference per day might easily be 200 Calories or about 7 per cent of the day's total Governments and food faddists have fought the dietitians for less [3] Nor is it different with the protein content of bread Figures from 7 to 10 per cent are given, and judging from analyses made on bread from London bakers this may happen in bread purchased in the same locality [4] As this may lead to an uncertainty concerning 13 5 grammes of protein out of the day's total of 80 to 100 grammes, the uncertainty is of the order of 13–17 per cent Such uncertainty hardly belongs to an exact science

Nor is this all The protein in bread is estimated by estimating the nitrogen present and multiplying it by a conventional figure —usually 6 25 This assumes that proteins have 16 per cent nitrogen in them This is untrue Some have more and some

[1] 1037 is the figure in PLIMMER (1921), *Analyses and Energy Values of Foods* H M Stationery Office,

[2] 1216 in ABRAHAMS and WIDDOWSON (1937) *Modern Dietary Treatment* Baillière Tindall & Cox In McCANCE and WIDDOWSON M R C Spec Report No 235 3rd ed this has been corrected to 1088

[3] Rubner versus the German Government during the War of 1914–18 (1916 1917 1919) *Arch f Physiol*

[4] Unpublished figures by W M Clifford

have less The conventional figure 6 25 is far from the true figure for egg albumin (6 45) or for gelatin (5 38) Thus according as the higher conventional figure or the more accurate lower figure has been used by the analyst there will be a difference of over 10 per cent

In the calculation of Calories conventional figures instead of the accurate figures have been used Thus all carbohydrate is lumped together and it is agreed to say that each gramme yields on oxidation in the body 4 1 kilocalories So if a food say a sweetmeat weighing 10 grammes, consists mainly of glucose its estimated caloric value will be 10 × 4 1 = 41 kilocalories whereas the actual value is 10 × 3 75 or 37 5, i e nearly 10 per cent less With the decrease in the consumption of starch (4 12 kilocalories per gramme) which is taking place to-day and the increase in cane sugar consumption (3 95 kilocalories per gramme) there results a small over estimate of the caloric consumption if we accept the conventional figure 4 1

The figure for protein (4 1 kilocalories per gramme) and that for fat (9 3) are both of them conventional *Which conventional figures are used must be stated by the analyst and dietitian* In the calculations made incidentally in the course of this book Rubner s conventional figures, as given above, will be used. There is no guarantee that the authors quoted will have used the same convention

If other uncertainties are to be enumerated we may point to the fact that 'fat' in a food analysis usually means 'petrol ether soluble substance" or even ' ether soluble substance ' This is certainly not always fat and not always metabolizable The nitrogen of foods does not always represent protein, and the carbohydrate may include (though not in more modern analyses) indigestible and therefore unmetabolizable material In fact in any analysis of food and in any estimate of the intake of proteins fats carbohydrates, Calories, etc , by a person on a known diet there is an unpleasantly large margin of uncertainty, an inexactitude which we wish were not there We cannot help it Life and money are too short to achieve accuracy in dietetics and we must be content with saying that A's diet contains the possibility of yielding 3000 kilocalories approximately The approximation certainly does not lie within 100 kilocalories so that in accepting 3000 kilocalories we are assuming no more than that the true value is probably between 2900 and 3100 The estimation of a diet s values to more than the second significant figure is absurd There is thus in the analysis tables which are the basis of our calculations in dietetics an uncertainty and inaccuracy which may be daunting to the neophyte and must be devastating to one who hot for certainty

in this our life" But as long as it is recognized and allowance is made for it, it is no bar to the usefulness of dietetics

There is, however, a second ground for inexactitude in dietetics and that is to be found in the extreme dietetic variability of the human race We can make average estimates, we may lay down average "laws" for the feeding of people their basal metabolism varies as a *function of their surface area*, *the average man needs* so many Calories per day and the average woman so many less We may speak of average figures, but if we apply these figures to the individual we are lost

Two good illustrations came to light as the 9th edition of this book was being prepared, the one in an article in the *British Medical Journal*[1] and the other in a book upon Mass observation[2] The *former is that of a boy, son of vegetarian parents, who at* [illegible] years of age weighed 4 stone 3 lb, was 4 feet [illegible] inches in height, and was intelligent and energetic His diet included but little animal protein—cheese and milk—the nitrogen output was low (about $4\frac{1}{2}$ grammes per day, equivalent to 28 grammes of protein) and his Calorie intake 800 daily This boy's height was normal for his age though he was 10 lb underweight as compared with the Christ's Hospital figures[3] Yet he seemed fit and healthy, though his protein intake was not half the normal and his Calorie intake about one third that recommended by the Technical Commission of the Health Committee of the League of Nations

The second example was that of an all in wrestler, a champion "And he says that to get that feeling [i e that you want to tear the other man into little pieces] you have got to eat meat and plenty of it He buys a whole joint at a time He eats whenever he feels like it not at any fixed time Once he tried a vegetarian diet for six months He wanted to try it and see if it was good for him He found that it made him feel fitter than ever before in his life but, as he puts it, '*I didn't seem to have that little bit* of fire So he came back to meat in the end'"[4]

Again the capacity for absorbing the nutrients in food may vary Thus McCance and Widdowson have shown that on the same diet one person may be in positive calcium balance and another in negative balance and Meulengracht that the use of purgatives may prevent the absorption of calcium One of us (G G) has a patient whose apparent need of vitamin C is three times the average need Such instances could be multiplied indefinitely

[1] LEONARD HILL (1938) *Brit Med Journ* **2**, 417
[2] *Britain by Mass observation* (1939) 127
[3] FRIEND (1935) *The Schoolboy* Heffer & Sons Ltd
[4] *op cit*

With such contradictory evidence one might reasonably ask whether there is any reliance to be put in quantitative results. There certainly is in average figures but they must not be taken too rigidly. It would be wrong to say to either of the people quoted above that he must change his diet to bring it nearer the normal and also wrong to say to the average man that he must imitate either vegetarian boy or meat-eating wrestler in departing from the normal. Even in carefully collected data on individual intakes in food we find extraordinary departures from the mean. In the case of men the Calorie figure per day varied from about 1800 to 5000 and the figure for women from approximately 1500 to 3100. The figures for total protein animal protein fat carbohydrate calcium phosphorus and iron varied from one figure to another nearly its double. There was no significant correlation between Calorie intake and body weight. Nor did there seem to be any relation between occupation and Calories on the one hand or between Calories and the percentage surplus or deficit in weight. A person might be overweight for height and far below the average Calorie intake or be normal in weight and yet take 5000 Calories.[1] Similar variations, though with not so large a spread were found for women.[2]

All these departures from the mean or average figure are not adduced here to cast discredit upon dietetics but to check the too eager student of the subject from applying the average rules which have hitherto been discovered in dietetics ruthlessly to all people. Dietetics is by no means 'totalitarian' in its 'laws'—in fact very much the reverse. It lays stress or should lay stress upon individual requirements and personal peculiarities and idiosyncrasies. Perhaps some day we may be able to explain why in the research quoted above[3] one subject a university teacher of 28 years, is slightly overweight on an intake of 1772 kilocalories per day, while another subject an electrician one year older, obtains 4955 kilocalories per day from his food and is not overweight. At present we have no explanation and it is a disservice to the science of dietetics to pretend that we have.

Dietetics though fundamentally quantitative has difficulty with the extreme variability of the individual. Nevertheless there are rules and quantitative rules for the majority, just as there are laws for the behaviour of the molecules in a gas if we take them in quantity. And just as physics discovers that the behaviour of

[1] Widdowson (1936) *Journ Hygiene* 36, 26 ... lows here set
[2] Widdowson and McCance (1936) *ibid* ... and Malone ... ancet 1945 2 467
[3] Widdowson *loc cit*

Some of us can remember acquiring the taste To the Spaniard the acquirement comes so early in life that olives appear to be an obvious and natural food Similarly tastes for food may be lost and distaste take their place Stefánsson has a story of a sailor who had acquired a distaste for fat in early life He had stolen some fat, was made by his mother as a punishment to eat a large quantity of it became violently ill as a result and thereafter " could eat no fat " Many of us can match such an observation A food may have been the cause of or accompanied some alimentary upset and after that that food tasted unpleasant The upset need not be alimentary It can be emotional A child may connect some food with discipline from parents and not be able to eat it for the rest of his life

Naturally these food habits are usually acquired in early life What one is brought up to eat that one likes As Stefansson puts it bread seems a natural article of diet to a Western civilization and rice something that one eats occasionally To an Eastern civilization rice seems to be the natural " staff of life ' and bread a not very interesting adjunct The rice eating Bengali in 1944 preferred to starve to death rather than eat wheat flour In various books and articles Stefansson has shown this principle to be working amongst his colleagues in Arctic exploration the Eskimos he met and the dogs who drew his sleighs Of his colleagues, the University men were the most willing to change their food habits To eat meat and little else for a year was an adventure—it attached itself to a conditioned reflex (adventure) and became part of it To those who had been brought up on but a few foods it was a hardship to live entirely on meat They hankered for bread and flour with disastrous results in one case It was the same with the Eskimos They would not eat what they were not accustomed to The males were less conservative than the females the children were experimental but always checked by the females Among the dogs it was the same Dogs brought up on fish had to be starved into surrender before they would eat caribou (deer) dogs brought up on caribou had to be starved into surrender before they would eat game, and so on Fortunately if the food were allowed to go putrid dogs would eat it whatever its source The females had stronger new food " resistance than the males Among human beings and dogs it is the females who teach food habits to the young

The wonder is that any food habits change for there is a circle " what one eats when young that one likes and hands on to one s offspring ' which theoretically should rotate for ever Fortunately there are progressive and rebellious spirits who break away from

family traditions travel and bring home new habits And there are the intellectuals who will not be subservient to their tastes None the less it takes a long time to introduce a new food It took at least 200 years for the potato to get a hold upon Europe, and the tomato a hundred years More recently the grape fruit has conquered us in England in about 30 years and it may be that the avocado pear, the lichee the persimmon and the grenadilla will be added to our lists of common foods more rapidly still

All this dietetics has to recognize It has to realize that there are limits set upon its scope of action It cannot be accurate to within definite wide limits because the composition of foods varies within wide limits It cannot lay down dietetic laws applicable to everyone because of the variation in men s needs (? habits) because some take more than their share (are pleonectic) and some take less than their share (are meionectic) It dare not impose as most food fad lists and fanatics try to impose, its discoveries concerning one man or group of men upon all and sundry It must realize that the psychology of the individual may play havoc with any plan of diet based even upon wide observation and that unfortunately therefore a poor diet may suit such a person better than a well-conceived diet Although its task is to educate the general public to the belief that a food is a food only in its capacity to supply fuel, building and regulative materials not in its capacity to please the palate at first bite, none the less it must recognize that food habits are fairly unshakable and that to do any immediate good it must work within the ambit of those food habits and prejudices One part of the work of practical dietetics is to feed the sick and this can only be done if their likes and dislikes are recognized. But another part of its work is to educate the individual the family and the state in the best methods of feeding themselves to advantage This will often mean the breaking down of food prejudices and the question is where in the vicious circle of food habits to make your attack The probable answers are (i) at the point when the mother has her first baby, (ii) sometime in adolescence when one is always hungry, and (iii) when the intellect takes charge if it ever does, of a person s reactions

CHAPTER II

THE FUNCTIONS OF FOOD (I) SUPPLY OF ENERGY

Food has been defined in the first chapter as anything which, when absorbed into the body through the alimentary tract, is capable of one or more of three things (i) furnishing the body with materials from which to produce heat, work, or other forms of energy (ii) enabling it to grow or to repair its wear and tear, and (iii) supplying regulators, or the raw materials for regulators of its functions of production of energy growth, and repair It will be noticed that this definition is *physiological* i e it deals with what the foods do in the body—what are their functions Perhaps the third function needs some explanation There are reactions which go on in the body at a definite speed in the normal person, but in the abnormal person may go faster or slower If the thyroid gland elaborates too much thyroxine its owner burns up fuel materials too rapidly, if too little, too slowly The iodine and the tyrosine from which the thyroid gland elaborates thyroxine are found in food Similarly the oxidation of carbohydrates in the cell is directed and regulated, among many other things, by thiamine riboflavine and nicotinamide three vitamins preformed in food Without these preformed catalysts the normal processes of the body will proceed at abnormal velocities or not at all This third function of food which will be dealt with in Chapters IV and V is a discovery of this century It received its main impetus in the second decade and has almost monopolized attention in research in dietetics to the present day

Though the outlook of the dietitian must be physiological, this does not mean that the outlook of the chemist can be dispensed with On the contrary dietetics must keep in close collaboration with the chemist without, however allowing his concepts to dominate the field too much Without the chemist and the biochemist we could not have obtained any idea of the nature and mode of operation of the vitamins They would still be mysterious something the cynosure of every food faddist and quack medicine

and food advertiser The more we know about their chemistry the more accurately we can use them in dietetics

On the other hand dietetics must keep in touch with the caterer It is not enough to know what substances are necessary for adequate nutrition we must know how and where to obtain them in foods and the most convenient and possibly the most economical ways of buying them To take an extreme example should an Arctic explorer live "off the land" as Stefansson and the late Gino Watkins did or should he carry food in its most condensed form from temperate climes ?

The outlooks of the three types of persons interested in dietetics are here arranged tabularly

The Physiologist	*The Chemist*	*The Caterer*
Foods are useful for—	These foods contain respectively—	These substances are found mainly in—
1 Energy production	1 Fat carbohydrates and (though not so important) proteins	1 Dripping lard suet butter margarine cereals, sugar dried fruits pulses, and things made from these
2 Growth and repair	2 Proteins mainly but to a less extent calcium iron etc	2 Milk eggs cheese fish and meat
3 Control regulation and direction of processes in the body	3 Mineral elements and vitamins	3 Dairy foods certain specified fruits and vegetables and the fat fish

This classification is not perfect nor is the alignment between the three columns perfect For instance although we in Great Britain obtain only about 10 per cent of our Calories from protein and as it were incidentally and by accident in the Arctic Circle perforce and among the Masai by choice 44 and 30 per cent of the Calories respectively are derived from protein Whereas it would be true to say that in Europe the energy value of our diet arises largely from the fats and carbohydrates it would not be so among the Eskimos and the male Masai Again the mineral elements in our diet are mainly used for catalytic purposes but (notably) calcium and phosphorus though essential for such purposes are also used in relatively enormous quantities for building the skeleton with the result that the child s and the adolescent s need for calcium and phosphorus is greater, much greater, than the adult's Further, it is true that whereas we get our energy producing foods mainly from the grocer and baker, and the body

The Carbohydrates comprise a group of substances more unlike each other superficially than are the fats, but none the less having more likeness in the building stones from which they are made As the name suggests, they are composed of the elements carbon hydrogen, and oxygen, the latter two being in the proportion of two to one as in water The elementary building stones of the carbohydrates important in food are the simple sugars containing six carbon atoms the hexoses or monosaccharides, glucose, fructose, and galactose, and into these monosaccharides all carbohydrate foods have to be resolved by digestion before they can be of use to the body Two monosaccharides united form the disaccharides, cane sugar (sucrose), malt sugar (maltose), and milk sugar (lactose), all of which have importance in dietetics Starch, glycogen, and dextrins are complexes of many monosaccharide building stones (glucose in every case) and are therefore called polysaccharides Not less than 24-30 glucose units, and it may be as many as 3000 units, are linked up to form starch,[1] 12 or 18 to form glycogen, and the dextrins have numbers approximating to that of starch and thence downwards to three, stable dextrin or trihexosan. All these polysaccharides which are condensation products of hexose sugars are called hexosans and all, or many of them may be found in a breakfast food such as cornflakes or grape nuts. Starch grains (particularly potato starch) have a substance amylopectin in them which is a hexosan united with phosphoric acid. It confers their well known insolubility on starch grains, and probably accounts for their indigestibility when uncooked Potato starch has most amylopectin (73 per cent) and rice starch least (38 per cent), and these figures may account for (i) the fact that uncooked potato starch causes colic, and (ii) that rice is eaten in Asia in a state less cooked than is usually tolerated in this country without mishap

Of the monosaccharides glucose is found in nature in fruits such as grapes, in vegetables, and in honey , fructose in the majority of fruits and in honey , while galactose is not found free [illegible] sugar, among the disaccharides is found in the sugar cane [illegible] in other root vegetables and in most fruits The com[illegible] "sugar" is practically 100 per cent cane [illegible] treacle contain 70 per cent hexose sugars Malt [illegible] malt and malted products and milk [illegible]

Starch is present in all the cereal [illegible] and in potatoes Dextrins occur [illegible] result of submitting starch [illegible] to diastatic enzymes Consequently [illegible]

[1] RICHARDSON (1941) [illegible]

Biscuits and breakfast foods and also the crumb of bread contain dextrins

Glycogen the only carbohydrate of animal origin, is found in liver in shell fish, and to a much smaller extent in all muscles (meat)

In addition to these carbohydrates which may be termed the "*available*" carbohydrates because the body can utilize them as fuel there are a number of substances occurring in fruits and vegetables which dietitians loosely and incorrectly comprise under the name "cellulose" They are plant cell wall products One pectin which is responsible for the "jelling" of jams is a mixed colloid with a pentose galactose or methylated galacturonic acid as the units of structure Others have derivatives of glucose mannose or galactose as their basic units Neither pure cellulose nor these other substances are digestible, absorbable or metabolizable by the body Their only function in diet is to hurry a meal along the alimentary tract owing (i) to their mechanical action (e g lettuce leaves the stomach more rapidly than many a digestible food) and (ii) to the irritating effect of the chemical products of their decomposition by bacteria in the large intestine The value of these "***unavailable***" carbohydrates or "***roughage***" in diet has been and still is over rated It is assumed that some roughage is essential in diet for normal people more still for those who possess a sluggish large intestine and it is possible that its absence from a diet is essential for those who possess a spastic colon

The fuel value of the available carbohydrates is assessed at 4 1 Calories per gramme although that of starch is nearer 4 2 while that of cane sugar is 3 95 and of glucose 3 75 4 1 is a "conventional" average figure In most food tables under the heading "carbohydrate" the figure for the available carbohydrate is given but in older tables often the carbohydrate of the fibre (i e cellulose, pentosans etc) is included and the Calorie value is too high

Proteins as stated above can be and are used by the body for the production of energy Indeed they are used entirely for that purpose if no carbohydrate is taken along with them at a meal[1] This is so because in the breakdown of their constituent amino acids in the liver they pass either through a carbohydrate (glucose) stage or a fatty acid stage and are oxidized as such A little more than half of the protein is oxidized via the glucose path and somewhat less than half goes by the fatty acid path

The conventional figure for the ***fuel value of protein*** is 4 1 Calories per gramme Outside the body the fuel value of protein burnt in oxygen is 5 6 Calories The reason for this discrepancy

[1] CUTHBERTSON and MUNRO 1939 *Biochem Journ* 33 128

For this there are two reasons (i) the figure it gives us is convenient to handle—it is expressed in thousands [1] rather than millions or billions, and (ii) all energy in the body, and elsewhere ultimately appears in the form of heat Our muscles contract and at once produce heat The friction in our joints produces heat To put our muscles into a condition where they contract again produces heat The stone we hurl through friction against the air produces heat In its final contact with the earth its kinetic energy is transformed into heat Moreover the transformation of heat energy into mechanical work involves a wastage of about *two thirds* of that energy—as heat As the body must be assumed to work in accordance with the laws (i e "rules") of thermodynamics—heat and work are intraconvertible in definite proportions, and it is impossible to produce a constant supply of energy by any isolated self acting machine—the majority of the energy of the body appears as heat In fact if you isolate the human body by placing it in a calorimeter (see below) all the energy it puts forth *must* appear as heat That therefore is the most convenient form in which to measure the output of energy by the body and therefore—energy being indestructible and uncreatable—the energy *needs* of the body We measure the output and needs of the body for energy by calorimetry

We have mentioned the Calorie as being the measure we adopt of the body s output or needs per day The Calorie is the amount *of heat requisite to raise the temperature of one kilogramme of* water (2 205 lb) one degree centigrade ($\frac{9}{5}$° Fahrenheit) [2] For those who think in pounds and degrees Fahrenheit as is 'natural" in this country the Calorie is almost exactly four times the size of the "natural British unit, i e the heat necessary to raise one pound of water one degree Fahrenheit

If the body gives out heat in the course of a day which would raise either 3000 kilogrammes of water through 1° Centigrade, or 300 kilogrammes through 10°, or 30 kilogrammes through 100°, we say that the body has given out 3000 (kilo or great) Calories This indicates that the food must supply 3000 (kilo or great) Calories to the body in the course of the day

[1] e g 3000 Calories per day instead of 1 292 000 Kilogramme metres 9 370 000 foot pounds or 1 265 000 000 000 000 ergs

[2] The actual unit of heat used by the physicist is the small calorie or the heat necessary to raise the temperature of 1 *gramme* (not a kilogramme or thousand grammes) of water one degree centigrade—a cause of considerable confusion The great Calorie or Kilocalorie should always be written with a capital C to distinguish it

Calorimetry

Direct Calorimetry There are two methods of direct calorimetry human calorimetry and food calorimetry *Human calorimetry* has been raised to a point of great accuracy Originally the calorimeter or container was the size of a tiny room 9 × 6 × 6 Such calorimeters are still in use and can contain a bed, or a table and chair, or a stationary bicycle with magnetic brakes upon which ' work ' may be done The room has copper walls and is enclosed within three other shells the inmost zinc and the outer two wood all insulated from each other A series of close fitting doors through these shells gives access to the calorimeter and there is a window through which food can be passed to the subject or excreta passed out for analysis

To measure the heat produced by the subject iced brine is circulated through radiators in the calorimeter The volume of brine circulated during the experiment is weighed, and this weight multiplied by the rise in temperature of the brine which is measured by very accurate electrical resistance thermometers gives a measure of the Calories absorbed by the radiators If we add to this the heat absorbed in vaporizing water in the lungs and by the skin, we have, subject to small corrections the total heat produced by the subject during the experiment The air in the calorimeter is purified by sucking it out with a rotary blower It is then passed through a container with sulphuric acid in it to remove moisture then through one with soda lime to extract the carbon dioxide, next through another container with sulphuric acid to trap any water from the soda lime, and last back into the calorimeter As the air would be depleted of oxygen if further oxygen were not admitted there is an apparatus attached which automatically allows pure oxygen to enter from a cylinder whenever the pressure within the calorimeter falls to an appreciable extent

The apparatus thus measures not only the heat given out during the course of the experiment but also the oxygen absorbed and the carbon dioxide and water given out by the subject We can from these data, together with the nitrogen excreted by the kidneys calculate what materials have been consumed in the body of the subject during the experiment

We can also, if the subject spends a long time in the calorimeter, compare the heat he gives out with the theoretical amount he could get from burning the food he has eaten This must be as explained above, the heat obtained from oxidizing the food in oxygen minus the heat obtainable from oxidizing the excreta in oxygen When the experiment is made as has been done many times it is found

the consumption of oxygen during that time If we make the assumptions that the protein consumed during that time is negligible and that the carbohydrates and fats during that time are completely consumed to carbon dioxide and water we can estimate the heat given out from the oxygen absorbed and the carbon dioxide exhaled The volume of carbon dioxide given out divided by the

Indirect Calorimetry by gaseous exchange

TABLE FOR CALCULATING CALORIE OUTPUT FROM OXYGEN ABSORBED

(After Zuntz and Schumberg modified by Lusk)

Non protein Respiratory Quotient	Calories per Litre O_2	Per cent Calories derived from	
		Carbohydrate	Fat
0 707	4 686	0 0	100
0 71	4 690	1 10	98 9
0 72	4 702	4 76	95 2
0 73	4 714	8 40	91 6
0 74	4 727	12 0	88 0
0 75	4 739	15 6	84 4
0 76	4 751	19 2	80 8
0 77	4 764	22 8	77 2
0 78	4 776	26 3	73 7
0 79	4 788	29 9	70 1
0 80	4 801	33 4	66 6
0 81	4 813	36 9	63 1
0 82	4 825	40 3	59 7
0 83	4 838	43 8	56 2
0 84	4 850	47 2	52 8
0 85	4 862	50 7	49 3
0 86	4 875	54 1	45 9
0 87	4 887	57 5	42 5
0 88	4 899	60 8	39 2
0 89	4 911	64 2	35 8
0 90	4 924	67 5	32 5
0 91	4 936	70 8	29 2
0 92	4 948	74 1	25 [illegible]
0 93	4 961	77 4	22 [illegible]
0 94	4 973	80 7	19 3
0 95	4 985	84 0	16 0
0 [illegible]	4 998	87 2	12 8
0 97	5 010	90 4	9 58
0 98	5 022	93 6	6 37
0 99	5 035	96 8	3 18
1 00	5 047	100 0	0 0

oxygen absorbed is called the respiratory quotient and during the post absorptive stage (i.e. 12-16 hours after a meal) is 0.82 From the Lusk table (p. 25) we see that every litre of oxygen absorbed should represent 4.825 Calories at a respiratory quotient of 0.82 Similar figures from the carbon dioxide evolved can be used

Actually it is usual following Benedict, to calculate the Calories from the oxygen absorbed, though Poulton in this country, gave evidence that it is better to calculate it from the carbon dioxide evolved on the grounds that all the oxygen absorbed does not reappear as carbon dioxide evolved In hospital practice it is usual to accept absorption of oxygen as a sufficiently accurate measure of the Calories probably evolved At any rate the measurement is accurate enough to aid the physician in diagnosis of such diseases as hyper and hypothyroidism, leukæmia and Addison's disease

Similar methods of estimation can be extended to measuring the heat output in various occupations—sitting standing sewing dressing and undressing (20 to 60 per cent increase) to rowing (1000 per cent. increase)—and have been very useful in fixing minimum rations for young recruits in the army But again it is too cumbrous and expensive to be used in estimating the Caloric values of diets

Indirect Calorimetry by food Intake As was said above, the average caloric value of carbohydrates burnt in the body is assessed at 4.1 per gramme that of fats 9.3 and that of proteins 4.1 Therefore from the analyses of foods we can calculate their Caloric value to the body To take an example

Suppose that we analyse a food and find that it consists of

Protein	5.0 per cent
Fat	10.0
Carbohydrate	20.0

Water and mineral material to 100

Then its Caloric value per 100 grammes would be

Protein	5.0 × 4.1 =	20.5
Fat	10.0 × 9.3 =	93.0
Carbohydrate	20.0 × 4.1 =	82.0
Total		195.5
or per oz	195.5 × 28 [illegible] = [illegible] 44	
or per lb	1.955 × 453.6 = 886.8	

For all practical purposes 196 per 100 grammes, 55.4 per oz or 887 per lb are sufficiently accurate values

Nor should the results be much less reliable if an educated but untrained person conduct the observation This is the method used in this country by McCance and Widdowson in their investigations of individual intakes, and the instructions they give to their investigators are here appended [1] [2]

INSTRUCTIONS

1 Weigh each kind of food separately just as it is served to you If raw, say so If you are eating any food such as fish or chops that contain bones or fruit with skin or stones, please say whether your weight included the waste

e g Kipper weighed with bones
Orange weighed without skin

There is no need to weigh the *waste* but please weigh any *food* you leave and deduct it from the food you first weighed out

2 If you weigh anything on a plate *do not forget* to subtract the weight of the plate before entering the result on the form

3 You need not bother to weigh eggs Just count them and put the number Sugar may be weighed or measured in lumps or by the teaspoonful (say whether level or heaped)

4 Please say whether your bread is white or brown

5 Do not forget to put down all sweets and chocolates under Extras

6 Please say whether your fruit was fresh stewed, or tinned in syrup For stewed and tinned fruit weigh the fruit and juice together

7 Do not include gravy in the weight of the meat measure the gravy separately in tablespoons Please say what kind of meat or fish you eat

8 It is a good plan to weigh out for yourself at the beginning of the week ¼ or ½ lb of butter and always use from this piece You need not then weigh the butter as you eat it but simply put ¼ lb of butter started' and ¼ lb of butter finished' when it is so If any of the butter weighed out to you remains at the end of the week say what it weighs

9 We are very anxious to know how much milk you drink per day and how you drink it so please weigh the milk *if possible or measure* it in tablespoons Say how much milk you drink alone and how much you put in a cup of tea, cocoa etc Do not forget to put down how many lumps or teaspoonfuls of sugar you take in your drinks

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[1] Widdowson, McCance and Widdowson (1936), *J Hygiene* 36, 269 293

[2] McCance, Widdowson and Verdon Roe (1938) *ibid* 38, 596

THIS INDICATES HOW TO ENTER THE RESULTS AND IS NOT MEANT TO BE A PLAN OF AN IDEAL DIET

Food	Amount	Weighed (Raw or Cooked)
BREAKFAST:		
Cornflakes	$\frac{1}{2}$ oz	—
Sugar	2 level teaspoons	
1 boiled egg	—	—
Bread (white)	2 oz	Toasted
Butter started	4 oz	—
Milk on cornflakes and in 2 cups of tea (no sugar taken in tea)	5 oz.	
DINNER:		
Irish Stew		
Mutton weighed with bone	2 oz	Cooked
Carrots	$1\frac{1}{2}$ oz	"
Potatoes (boiled)	$3\frac{1}{2}$ oz	"
Gravy	2 tablespoons	"
Stewed plums weighed with stone	3 oz	
Boiled custard (made with egg)	2 oz	
TEA:		
Bread (white)	$3\frac{1}{2}$ oz	—
Butter from $\frac{1}{2}$ lb	—	—
Jam	1 oz.	—
Plain cake	2 oz	—
2 chocolate biscuits (cigarette size)	$\frac{1}{2}$ oz	—
Milk in 2 cups of tea	2 tablespoons	—
SUPPER:		
1 cup of cocoa:		
Cocoa	$\frac{1}{4}$ oz	—
Milk	4 tablespoons	—
Sugar	1 teaspoon (level)	—
2 plain biscuits (digestive)	1 oz	—
1 apple (weighed with skin and core)	3 oz	Raw
EXTRAS		
Milk at school	$\frac{1}{3}$ pint	—
Boiled sweets	1 oz	—

will be estimated. The item which will have greatest influence on the total will be the meat, for the other items which supply the bulk of the Calories—bread, butter, milk, and sugar—should have no waste.

Unfortunately the edible portion is not wholly consumed. It is inevitable that some should stick to the plate and to knives and forks. The fat of meat is often discarded, unpleasant looking portions are dissected away (e.g. veins), burnt and underdone portions put aside.

This table wastage is an individual affair. It is lowest among the poorest[1] and during times of scarcity[2]. It depends upon training and is greater in one country than another. Institutional feeding apparently leads to great wastage, though training may keep the table wastage as low as 1 per cent[2]. It may rise much higher[3] and in institutions known to us it has risen over 10 per cent. In estimating an individual's diet, when the food is weighed at table it is quite possible to allow for table wastage, but in calculating the value of the diet of a family or institution this is by no means easy. There are losses due to carelessness in preparing the food. One person will pare away much more of a potato than another. One cook will utilize much less of the fat that cooks out of a joint than another. Sauces, even "pouring sauces," will not wholly leave the saucepan for the sauce boat or the sauce boat for the plate. Consequently we can give only an approximate figure for the food consumed by a group of people—an outside figure. It is usually thought that the actual amount consumed is as much as 10 per cent below this outside figure and that allowance is commonly made. It ought, in a well regulated family or institution, to be considerably less.

Edible portion minus kitchen and table wastage we may term "input"[4]. This "input" food is never wholly digested and absorbed by the alimentary tract. There are indigestible fibres in plant and animal foods which are not only unabsorbable by the alimentary mucous membrane but also prevent the absorption of otherwise absorbable products of digestion. By hurrying food along the small intestine they may impede complete absorption. Sometimes as much as 20 per cent of a food material is lost to the body owing to incomplete absorption[5]. Moreover the alimentary

[1] CATHCART and MURRAY (1931) *Med Res Council Spec Rep* No 151

[2] FRIEND (1935) *The Schoolboy* Heffer & Sons Ltd

[3] GEPHART (1917) *Boston Medical and Surgical Journal* 176, 17

[4] We have borrowed this term from wireless telegraphy as a convenient if ugly word

[5] See below, p 145 under "Availability"

tract and its secretory glands may have to pour out more digestive juices and lubricating material on some foods than others The net gain to the body (which alone concerns us) will be greater when there is less outpouring of digestive juices

Estimates have been given of the loss of Calories through non absorption of various foods and in mixed diets The following figures are given

	Per Cent
Rice	2 6
Milk	4 4
Bread	4 5
Meat	5 5
Potatoes	6 8
Carrots	20 2

(RUBNER)

For the mixed diets we can calculate that 4 per cent , 7 per cent , and 11 per cent., respectively of the input Calories are lost through defective absorption in the following diets (i) Diet containing much animal food, (ii) diet containing a moderate amount of animal material, (iii) diet containing little animal material [1]

Input ' Calories minus loss through defective absorption we may term ' Intake ' Calories By the principle of the conservation of energy intake ' Calories must, eventually, and when the body is in equilibrium, equal output ' Calories, i e the Calories as measured by the calorimeter

We have therefore a means of estimating roughly the Calorie output or the Calorie needs of a person or group of persons, by collecting data of their food consumption and calculating the Calorie value of the foods eaten from analysis tables The method involves but a little arithmetic and intelligence and is far easier than the more scientific and direct methods of estimation by human Calorimetry or via gas analysis Its results however must not be unreservedly accepted

We may sum up the relations of the figures as given in the analysis tables to the actual output of energy by the subject of experiment thus

As purchased (usually abbreviated to A P) minus waste (bones, peel, core, etc)	= Edible Portion
Edible portion (usually abbreviated to E P) minus table waste	= Input
Input minus unabsorbed or secreted material	= Intake

Intake must equal Output when the body is in equilibrium

[1] WATT *U.S Dept of Agriculture* Bull 53

The relation of these values to one another is a variable one We have seen that the relation E P to A P may be 1 1 (bread, milk, butter), or it may be as low as 1 8 (nuts) We cannot give any average figures and it is absurd to pretend to do so The tables give the relation when wanted In calculating the Calorie value of a diet we have merely to be careful to see which set of figures is appropriate

How much is wasted at table is a variable quantity depending largely upon training and the loss due to incomplete absorption plus secretion of digestive juices varies from 4 to 10 per cent or more depending upon the nature of the diet It is a convention to assume that the two together approximate to 10 per cent

If this be true, the Calorie value of the edible portion of food minus 10 per cent will equal the Calorie value of the intake and this *in turn the output of Calories by the body* *Ordinarily* we do not concern ourselves so much with the output of Calories by the body but by the more easily estimated Calorie value of the food bought We speak of the Calorie value of a diet, meaning by that the Calorie value of the food eaten without making any allowance for unavoidable waste on plate or in the alimentary tract This is in fact the Calorie value of the edible portion

Group Dietaries Often we wish to know the average value of the diets of a group of people, whether of the family, institution or a nation This presents no real difficulty except in interpreting the results

The Housekeeping Method If the family is the unit [1] the food in the house at the beginning of the period of investigation (usually a week at least) is estimated and allowance is made for that at the end of the period All food bought during the time is weighed and so is the waste The food consumed equals that of *each commodity at the beginning* plus that bought during the period minus that at the end and minus the waste Usually in such an investigation the wastage of each food (crusts of bread etc) can be ascertained and we can obtain a fair measure of the Calorie protein fat carbohydrate mineral elements and vitamin content of the whole diet and therefore the input of the family

Much the same methods will be used in an institution e g a boys school The accounting department of the institution can supply the data for the food entering the institution in a definite period and assuming no leakage this gives over a period such as *a month or a term* the gross consumption of food From this must

[1] CATHCART and MURRAY (1931) *Med Res Council Spec Rep Series* (1931) No 151 and 1932 *ibid* No 165

be subtracted the wastage which may be itemized if the accounting department is efficient It may be waste bread, waste fat (either sold to soap merchants or converted on the premises into soap), or garbage which goes to the pigsties If the amounts of the two former are known their dietary value can be directly assessed, but if all waste goes into the garbage an analysis of mixed samples is essential for accurate evaluation of the loss Usually all the wastage goes to the pigs and it is difficult to make an allowance for it except in vague approximations Where the waste is small this does not much matter For example fairly careful estimates of the nature of the waste at Christ's Hospital[1] suggest that it accounts for on the average but 0 7 per cent of the total gross Calorie value of the food In other institutions the table wastage may be much greater e g St Paul's School Concord U.S.A[2] where it was in the Upper School 22 per cent in the protein 23 in the fat and 7 in the carbohydrates In public schools in this country the weight of the table wastage is often some 10 per cent of the food served though in a vegetarian house of a school investigated by one of us where there was very little cooked food served the waste was practically negligible (Clearly much can be done to cut down the wastage and caterers should consider a high wastage a sign of bad catering and bad training of the recipients of the food)

The net Calories after subtraction of the Calorie value of the waste divided by the number of people fed and the number of days in the period of estimation, gives the average Calorie intake per person per day

This method gives a satisfactory and understandable result if all the people under consideration *are of the same age and sex* This is rarely the case except in some institutions such as the army and some public schools where all can be counted as adults Usually women and children are included For example in a preparatory school *there may be children from about 6 years of age to 14* maids matrons and masters all fed from the same stores and kitchen In a public school there will almost invariably be kitchen staff infirmary staff, and housekeeping staff to complicate the Calorie issue In a co-educational school the complication is still greater

There has been a conventional method of obviating the difficulties involved by these complications It is known that on the average a man eats more than a woman and both more than a child say of five It is also known that their Calorie output varies in a

[1] FRIEND (193.) *The Schoolboy* Heffer & Sons Ltd

[2] GEPHART (1917) *Boston Medical and Surgical Journal* 176 17

similar way So dietitians in the past have composed scales of values purporting to represent the Calorie needs of children at each age and of women expressed as fractions of the need of an adult male The needs of the adult male in sedentary occupation are taken as unity He has a 'man value of 1 00 while the adult female is given another value (e g 0 83 or 0 7 according to whose scale you adopt) which is her ' man value " "index ' or 'co efficient Children are given coefficients according to their age e g at 3 years of age the coefficient given may be 0 5—the " man value of this child is half that of his father and so on Of such scales there were in 1936 no less than thirty eight [1] and they have received additions and complications since

Such scales have been used in this way Suppose we wish to assess the Calorie needs of a family consisting of a father (say a lawyer) his wife son of 14 daughter of 10 and two domestics, and we adopt the Cathcart and Murray scale

Father	= 1 00
Wife	= 0 83
Son of 14	= 1 00
Daughter of 10	= 0 80
2 maids	= 1 66
Total	5 29

One ' man = 3000 Calories Therefore the total Calorie needs is 5 29 × 3000 = 15 870 or (say) 16 000 per day

A boarding school or other institution can be reckoned in the same way

200 boys all 14 or over [2]	= 200 × 1 00	men	= 200 00
10 male teaching staff	= 10 × 1 00		= 10 00
5 female	= 5 × 0 83		= 4 15
5 male non teaching staff	= 5 × 1 00		= 5 00
10 female	= 10 × 0 83		= 8 30
	Total		227 45

Daily Calorie needs = 227 45 × 3000 = 682 350 or say 700 000 Calories

This method of calculation seems to us to have no advantage whatever over saying that a man s needs are 3000 per day a boy of 14 a 3000 an adult woman s 2500 a girl of 10 s 2400 and adding these figures But perhaps the method is held to be of value when different occupations are to be taken into account

[1] WIDDOWSON (1936) *Journ Hygiene* 36 269

[2] All later scales quite rightly give a much higher assessment for adolescent boys

It is known that *on the average* the needs of an agricultural labourer are more than those of a professional man The agricultural labourer's ' man value ' is often taken at 1 3 Suppose that among the male non teaching staff of the school considered there is a gardener Then we should have to separate out this staff into 4 × 1 00 and 1 × 1 30 and make their ' man value " 5 3 instead of 5·00 We cannot see any particular gain in this method of computation

In former editions of this book we have given a few of the more popular of the tables used and anyone interested in them may find them there We have come to the conclusion that the index should be discarded because (i) it tells us nothing new (ii) it hardly shortens any calculation (iii) it applies only to Calories but there is a danger that it may be applied to first class protein calcium [1] iron and vitamin intakes and even the cost of living It is a waste of time and energy to have an index or man value for each of the essential principles of diet (iv) it is based on an assumption or set of assumptions which bear little relation to fact—of which see later and (v) it makes dietetics appear more ' scientific ' than it is

Scales of Calorie values based on ' man values ' are distinctly suspicious commodities This is unfortunate, for that suspicion corrodes the value of all the work done on group diets from the Great War until the publication of Sir John Orr's book *Food Health and Income*, 1937 We have to take them ' for what they are worth ' and their worth depends upon values largely subjective It is regrettable that the family or group diet should be investigated via the individual diets of each member of the group This will receive further confirmation when we study factors of diet other than Calories

Despite these considerations, it is essential for practical purposes that some yardstick should be adopted A standard may be wrong and unscientific but it is better than none at all All standards in dietetics are based to a great extent upon guess work influenced by personal predilections and are therefore open to suspicion But it must be remembered that the guess work is that of intelligent scientific men trained in dietetics and therefore more likely to be near the truth than the guess work of the layman The guesses we are choosing to hold up for inspection and use are those of the National Research Council of the United States After all the science of dietetics has flourished much longer and more fully in

[1] One well known dietitian fell into the error of applying the index to calcium needs The Calorie ' index ' for a child of 3 may be 0 5 but its calcium index may be 1 2, and its cost of living index 0 75

given out by the body in ordinary conditions of life, and have given more than a hint, which will be justified later that there is as yet no fixed quantum of heat output which we can say is "correct for any individual We have indicated that in the normal person who is neither gaining weight nor losing it—who in other words is in equilibrium—the output of Calories exactly equals the intake of potential Calories in the food assimilated And we have given an account of means by which the output of Calories can be measured and the putative intake of Calories can be measured from the input

We naturally ask is there anything fixed and constant in the energy output of an individual, from which we can build up a quantitative science of dietetics? Does the human being never behave like a machine in which so much fuel burnt produces so much energy? The answer is that Basal Metabolism provides the indication that it does

What happens to the body when there is (i) an insufficient input and (ii) no input at all (i e starvation)? In both cases the body is forced to consume its own muscles or its fat and carbohydrate depots to meet the inevitable demands for energy Whenever the body receives less Calories than it gives out there is a loss of weight and we utilize this fact when we are wanting to get rid of an excess of body weight The matter will be discussed in a later chapter under the treatment of obesity What concerns us now is basal metabolism i e the inevitable loss of heat from the living body when at rest and its relation to total metabolism in order to see if we can give any theoretical figure for the output of Calories per day

The animal body unlike the non living machine needs food for its maintenance and repair even when at rest The body never is at rest completely, even when in a state of extreme quiescence The heart pumps blood against pressure through arteries and capillaries The chest muscles do mechanical work in respiration Probably even the muscle tone of the striped muscles consumes energy which needs replacing Energy is needed for the secretion of fluids by the body e g saliva sweat and urine, and also for some of the chemical transformations which occur in the body There is therefore a loss of energy from the body at rest and this loss is expressed as a loss of heat

This inevitable production of heat when at rest is the base line, the jumping off ground of metabolism It is presumably its irreducible minimum A whole literature has grown up round the study of this irreducible minimum which is termed basal metabolism' For the human being the basal metabolism is taken to

be the output measured in Calories of the body in a state of complete rest some twelve hours after the last meal. The time most convenient for the estimation is in the morning after the night's sleep. The subject of the experiment is placed in a Calorimeter and his heat output measured over a period of one to two hours. The daily basal metabolism is calculated from the result obtained. Experiments upon animals (swine) suggest that the body does not reach its basal output quite so soon as twelve hours after the last meal but the results are sufficiently near the basal value to be of great practical use. For details of the methods of estimation of the basal metabolism, readers are referred to the original treatises on the subject.[1] What we have to consider now is the influence upon basal metabolism of such factors as height, weight, and skin area, of age and sex and of the endocrine organs.

Influence of Height, Weight and Skin Area upon Basal Metabolism. Arguments from first principles suggest that the shape and composition of the body will influence its metabolism, and that surface is of paramount importance. The larger the surface of the body relative to its bulk the greater is the amount of heat lost by radiation. A reference to the accompanying diagram (Fig. 2) will make this clear.

Let us suppose that we have two bodies the first being 9 feet high 3 feet broad and 1 foot thick and the second measuring 3 feet in every dimension. Both will have a content of 27 cubic feet but the first will have a surface of 78 square feet the second of only 54 square feet; in other words the surface exposed is almost one third greater in the one case than in the other. If heat is lost at a rate comparable with the area the amount of heat lost will also be proportionately greater. The first of these figures would represent the condition of a tall thin man, the second that of a short stout man and as the former must lose about one third more heat than the latter, his basal metabolism will be one third higher than the latter's. That this is borne out in fact is

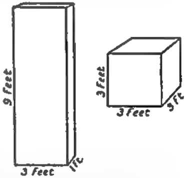


FIG. 2.—TO ILLUSTRATE THE INFLUENCE OF SHAPE ON AREA OF SURFACE.

[1] DU BOIS (1936) *Basal Metabolism in Health and Disease*. Baillière, Tindall & Cox. See also ADAMS and POULTON (1932) *Jour. Physiol.* 77, Proc. 1.

the opinion of such physiologists as Rubner, Graham Lusk and Du Bois who appear to have made out an excellent case for their contention When we find that if we are careful to measure the area of animals so different as dogs, horses mice and men, the output of Calories per square metre is approximately 1000 per day we may be sure that we have reached something fundamental even if we cannot pretend that we have the whole explanation [1]

None the less there is a school which still prefers to relate the basal metabolism to weight instead of area and it is usual to calculate (say) the protein requirements of a diabetic in reference to his weight rather than to his area Of course the heavier the body—i e the greater the number of cells which it contains—the greater is the output of energy, for each cell yields its quota But this is true as a general statement only for the kind of cell must also be considered The energy outputs of a pound of bone, a pound of fat cells and a pound of muscle cells must be very different Fat and bone have a low rate of metabolism Their activity and therefore their heat output is small Muscle, on the other hand is a very active tissue and the same may be said of many of the glands On this argument the man with heavy bones or much adipose tissue should have a basal metabolism smaller per pound than the thin and wiry individual Those who take this position must maintain that it is the mass of active cells in the body which determines the basal metabolism

To these it may reasonably be answered that as we have no conceivable way of measuring the mass of active cells in the body, the consideration does not help us in any but a negative way and that as the assumption that basal metabolism varies with area has a large mass of *data* to back it it is as well to adopt that assumption Moreover any ordinary estimate of area of the body includes factors representing height or weight [2] [3] consequently when we calculate

[1] Physicists may be tempted to explain the area effect as an illustration of Newton s law of cooling in which the rate of loss of heat varies directly with the area of the body *and the difference between its* temperature and the temperature of the surroundings That this does not apply to man is clear from the fact that the basal metabolism does not fall to zero when the temperature of the atmosphere rises to or above body temperature—indeed it falls but very little being much the same in Java as in Holland

[2] MEEH $S = K \times \sqrt[3]{W^2}$ K is a constant = 0 12312

DU BOIS $S = W^{0\ 425} \times H^{0\ 725} \times 0\ 007184$

[3] See tables and curves for calculating areas from data of height and weight in DU BOIS *Studies in Basal Metabolism* or in M S ROSE s *Foundations of Nutrition* The nomogram on p 48 gives a ready means of estimating surface area and the value of Basal Metabolism

basal metabolism in relation to area we are at the same time relating it to height or weight. The formulæ for calculating skin areas have been shown to have a reliability of about 5 to 10 per cent, even in extreme cases, and the Calorie value per square metre based on the formulæ are fairly constant from individual to individual and even from race to race and species to species.

The figure for an adult male is approximately 40 Calories per square metre per hour (960 per 24 hours), or taking the area of an average male as 1.75 square metres this represents a basal metabolism of

$$40 \times 1.75 \times 24 = 1680 \text{ Calories per day}$$

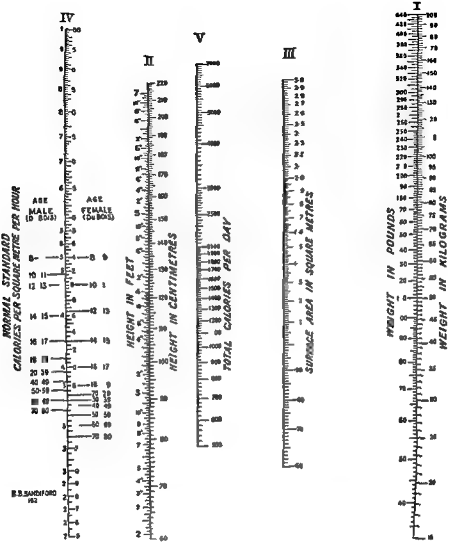
Influence of Sex and Age upon Basal Metabolism. As might be expected the basal metabolism of the adult female[1] is lower, viz. 37 Calories per square metre or 1330 Calories per day for a woman of 1.5 square metres area.

Once an individual has reached adult age the figure remains very nearly constant. It does, however, fall gradually, till in old age it has decreased to 90 per cent. of its former value. This is true of both women and men.

On the other hand the basal metabolism of infants, children and *adolescents shows a very different picture. It starts at about 30 and* rapidly rises till at 6 years it reaches a peak of 60 Calories per square metre—a rate 50 per cent. greater than that of the adult. Thence it falls fairly rapidly at first and then more slowly till it reaches the adult figure of 40. According to Du Bois there is a second peak at or about the age of puberty when the Calorie figure rises to 50.

In general we see that the vigorously growing tissues of the young have a much more active metabolism than the mature tissues of an adult, even though the body is resting and fasting. This accords with the fact that the food requirements of the young have no direct relation to age or to weight. That there should be a rise in the basal metabolism in adolescence is not unexpected. It is a period of rapid growth in the first place and in the second there is the stimulating effect upon metabolism of endocrine organs, particularly thyroid and pituitary. So far as experiment has gone this pubertal rise has not been observed in animals. A nomograph for finding the

[1] Is there any fundamental reason why female protoplasm with its XX chromosomes should have a different efficiency from that of male protoplasm with XY chromosomes? From anatomical investigations and data of athletic prowess it seems that there is. It would be interesting to have calorimetric data of androgynes, of bisexual pigs, of freemartins and intersexual birds and investigations of the oxygen intake of slices of tissues under the influence of œstrone and testosterone respectively.



By permission from Price's Textbook of Medicine (Oxford Medical Publications)

FIG 3.—BOOTHBY AND SANDIFORD'S NOMOGRAPH

The weight in pounds or kilogrammes is shown on Scale I. The height in inches and centimetres is shown on Scale II. The surface area in square metres is shown on Scale III. The normal standard calories per square metre of body surface per hour are shown on Scale IV. The total calories per diem are shown on Scale V.

Directions.—Keep the chart flat. Use a flexible ruler with a straight edge or a strip of stiff paper such as a postcard. (A) Locate the point on of the weight and height on Scales I and II respectively. Apply the straight edge of the ruler and note where it cuts Scale III. Read the figure on Scale III which will give the surface area of the body in square metres. (B) Locate the surface area on Scale III and the normal standard Calories per square metre per hour for the age and sex of the subject on Scale IV. Apply the straight edge of the ruler and see where it cuts Scale V. Read this figure which gives the total basal calories per 24 hours.

Large-scale nomographs may be obtained from W. B. Saunders Co., West Washington Square, Philadelphia, U.S.A., or from H. V. Elmer, 1641 Monadnock Buildings, Chicago, U.S.A.

normal basal metabolism of a person of given sex, height weight and age is given in Fig 3

Other Factors Influencing Basal Metabolism That the relation between area and basal metabolism is not quite so constant as has been suggested above is shown by the fact that the *previous history* of the person or animal under experiment does have some influence upon the basal metabolism [1] A period of under nutrition lowers the basal metabolism [2] a period of heavy exercise raises it A holiday in the country raised the basal metabolism of the experimental animals of the Russell Sage Institute though it soon returned to the normal in the surroundings of New York Doubtless this is true of man Sleep if deep, results in a lowering of the basal metabolism by some 5 or 6 per cent

The influence of such a gland as the thyroid is great Of all the endocrine organs it is the one which has greatest influence on metabolism In cretinous and myxœdematous patients this falls 10 20 and even 40 per cent below the normal and in hyperthyroidal persons it may rise to even 100 per cent above the normal So marked is the influence of the thyroid that the measurement of basal metabolism is used in diagnosing thyroid disease and the effect of treatment upon that gland The pituitary anterior lobe and the suprarenal also have great influence upon the basal metabolic rate

To sum up this section upon basal metabolism i e the metabolism of the body in a state of rest 12 or more hours after food intake, we may say that—

(1) It is approximately constant for the individual

(2) It is constant per square metre body surface for men and animals

(3) The figure per square metre per hour is 40 for the adult male and 37 for the adult female

(4) The figure falls somewhat with advancing age

(5) In children it rises to 60 at the age of six with a second peak of 50 in adolescence [3]

(6) Previous history has some influence upon it

(7) Pathological conditions of the body, particularly thyroid, pituitary suprarenal (cortex and medulla) disorders and fever influence it very markedly

[1] See Du Bois *op cit* 160

[2] See Wishart (1934) *Journ Physiol* 82 189

[3] Nitschke and Schneider (1932) (*Zeit f Kinderheil* 50 1) find an average deficit in rachitic infants of 17 5 per cent Giving a vitamin D concentrate raises the basal metabolism in these infants but not in normal infants

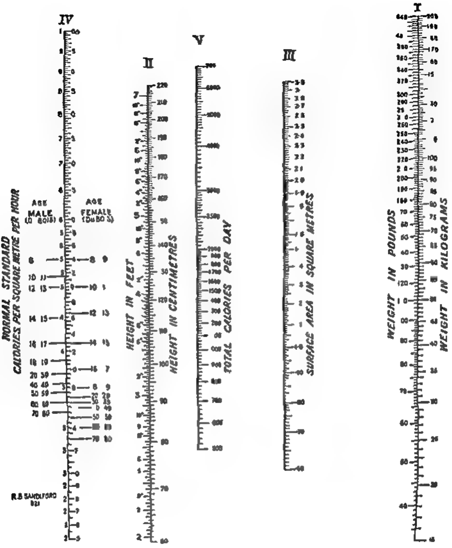


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FIG 3 —BOOTHBY AND SANDIFORD'S NOMOGRAPH

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Directions —Keep the chart flat Use a flexible ruler with a straight edge or a strip of stiff paper such as a postcard (A) Locate the position of the weight and height on Scales I and II respectively Apply the straight edge of the ruler and note where it cuts Scale III Read the figure on Scale III which will give the surface area of the body in square metres (B) Locate the surface area on Scale III and the normal standard Calories per square metre per hour for the age and sex of the subject on Scale IV Apply the straight edge of the ruler and see where it cuts Scale V Read this figure which gives the total basal calories per 24 hours

Large scale nomographs may be obtained from W B Saunders Co West Washington Square Philadelphia U S.A or from H N Elmer 1641 Monadnock Buildings Chicago U S A

normal basal metabolism of a person of given sex, height, weight, and age is given in Fig. 7.

Other Factors Influencing Basal Metabolism. That the relation between area and basal metabolism is by no means constant has been suggested above; it is shown by the fact that the previous history of the person or animal used for experiment does have some influence upon the basal metabolism. A period of under-nutrition lowers the basal metabolism;[1] a period of heavy exercise raises it. [illegible] in the [illegible] raised the basal metabolism of the experimental animals [illegible] the adult women [illegible] to the normal in the surroundings of New York. Doubtless this is true of man. Sleep, if deep, results in a lowering of the basal metabolism by some 5 or 6 per cent.

The influence of such a gland as the thyroid is great. Of all the endocrine organs it is the one which has greatest influence on metabolism. In cretinism and myxoedematous patients it falls 10, 20 and even 40 per cent below the normal, and in hyperthyroidal persons it may rise to even 100 per cent above the normal. So marked is the influence of the thyroid that the measurement of basal metabolism is used in diagnosing thyroid disease and the effect of treatment upon that gland. The pituitary anterior lobe and the suprarenal also have great influence upon the basal metabolic rate.

To sum up this section upon basal metabolism, i.e. the metabolism of the body in a state of rest 12 or more hours after food intake, we may say that—

(1) It is approximately constant for the individual.

(2) It is constant per square metre body surface for men and animals.

(3) The figure per square metre per hour is 40 for the adult male and 37 for the adult female.

(4) The figure falls somewhat with advancing age.

(5) In children it rises to 60 at the age of six with a second peak of 50 in adolescence.[2]

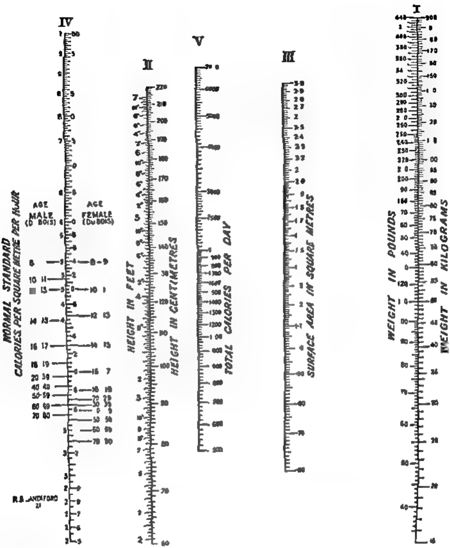
(6) Previous history has some influence upon it.

(7) Pathological conditions of the body, particularly thyroid, pituitary, suprarenal (cortex and medulla) disorders and fever, influence it very markedly.

[1] See Du Bois, *op. cit.*, 160.

[2] See Wishart (1934), *Journ. Physiol.*, 82, 189.

[3] Stricker and Schneider (1932) (*Zeit. f. Kinderheil.*, 50, 1) find an average deficit in rachitic infants of 17.5 per cent. Giving a vitamin D concentrate raises the basal metabolism in these infants but not in normal infants.



By permission from Price's Textbook of Medicine (Oxford Medical Publications)

FIG 3 —BOOTHBY AND SANDIFORD'S NOMOGRAPH

The weight in pounds or kilogrammes is shown on Scale I The height in inches and centimetres is shown on Scale II The surface area in square metres is shown on Scale III The normal standard calories per square metre of body surface per hour are shown on Scale IV The total calories per diem are shown on Scale V

Directions —Keep the chart flat Use a flexible ruler with a straight edge or a strip of stiff paper such as a postcard (A) Locate the position of the weight and height on Scales I and II respectively Apply the straight edge of the ruler and note where it cuts Scale III Read the figure on Scale III which will give the surface area of the body in square metres (B) Locate the surface area on Scale III and the normal standard Calories per square metre per hour for the age and sex of the subject on Scale IV Apply the straight edge of the ruler and see where it cuts Scale V Read this figure which gives the total basal calories per 24 hours

Large scale nomographs may be obtained from W B Saunders Co West Washington Square Philadelphia U S A or from H N Elmer 1641 Monadnock Buildings Chicago U S A

[illegible]

8 hours' sleep at a basal metabolism [illegible] = [illegible] Calories
[illegible] = [illegible]
8 hours' work at [illegible] = [illegible]

Total = [illegible]

about [illegible] Calories per day

The third item needs some explanation. It has been estimated that a moderate amount of muscular work represents 100,000 kilogramme-metres ([illegible] foot-tons) for one day.[1] The heat equivalent of this is 235 Calories. No machine using fuel can transform all the energy of oxidation of the fuel into work. In fact the efficiency of the most perfect machine working at ordinary temperatures cannot rise above about one-third, i.e. it transforms only one-third of the heat energy used into mechanical work, and wastes the remaining two-thirds. Most engines are very much more wasteful than this, e.g. the efficiency of the steam engine is about 10 per cent. only. If we make the assumption that the efficiency of the body is at the high level of one quarter, the performance of mechanical work in 8 hours equivalent to 235 Calories entails an expenditure of 235 × 4 = 940 Calories.[2] To this we must add the

[1] A measurement of the work done by a long-distance cyclist during 8 hours' pedalling on an ergometer gave the result of [illegible] kilogramme-metres. Wishart (1934) *Journ. Physiol.* 82, 189.

[2] In experiments upon trained cyclists pedalling against known brake resistances in a calorimeter, Benedict and Cathcart showed that every extra Calorie of work needed 3.343 extra Calories of energy—an efficiency of nearly 30 per cent. Quoted in *Med. Res. Council Spec. Rep.* (1918) No. 13.

Basal Metabolism and Total Metabolism

That total metabolism i e the total energy output of the day on full diet bears some relation to basal metabolism hardly needs stating Total metabolism includes the work done in carrying one s

Calories Required for Basal Needs of the Body and Waste in the Excreta (after Holt)

Age	Basal Needs	Wasted in Excreta	Growth	Activity	Total
1 year	500	150	200	150	1000
2 years	650	150	200	150	1150
3	700	150	200	200	1250
4	750	150	200	250	1350
5	800	150	200	300	1450
6	800	150	200	400	1550
7	850	150	200	520	1720
8	920	200	200	630	1950
9	1020	200	200	680	2100
10	1080	200	200	740	2220
11	1100	250	220	880	2450
12	1100	300	280	1020	2700
13 ,	1180	320	280	1220	3000
14 ,	1300	350	400	1350	3400
15	1400	400	600	1400	3800
16	1500	380	420	1680	3980
17 ,	1550	300	250	1720	3820
18	1550	300	100	1630	3580
19	1550	300	—	1580	3430
20	1600	350	—	1300	3250

body about and so varies with the *weight* of the body Basal metabolism varies with the *area* of the body which has a mathematical relation to the height and weight Consequently total metabolism is influenced by basal metabolism Clearly the ***physical work*** undertaken immensely influences the total metabolism Heavy physical work entails an output of energy which must be made good either by the consumption of food or of the tissues of the body Therefore an increase of physical work entails an increased consumption of food

There are thus three sources of the energy output per day, viz

1 The basal metabolism
2 The energy output due to being up and about
3 The energy output due to mechanical work

[illegible] the general agreement that the average Calorie intake for the adult male should be about 3000 and that of the adult female 2500 (or it may be 2300), but this figure is [illegible]. There are always people even [illegible] that it might be lower. The [illegible] may be [illegible] in [illegible] to the contrary. It is almost certain that one factor in the winning of the war of 1914–18 was the better feeding of the armies and the populations of the Allied Nations as against that of the central European countries. Whereas we in Great Britain were allowed more than 3000 Calories per head per day, the official (and therefore [illegible]) figure for Germany was 1000 and [illegible]. In 1936 [illegible] potential recruits to the British Army [illegible] were sent back to [illegible] by a special course of training plus a diet which supplied 4000 Calories per day. At the end of three months [illegible] were up to the physical requirements and six [illegible] be [illegible].

More [illegible] made by [illegible] which have been quoted to uphold the idea that 3000 Calories per day is luxurious do not seem to bear that interpretation. Two squads of students cut down their food intake to about 2000 Calories per day for a period of fifteen weeks. The effect was to lower the body weight till a new equilibrium was reached and there was a fall in basal metabolism. This showed that it is possible to keep a constant, though relatively low bodyweight on a lower Calorie intake. Further, some of the squad could maintain athletic ability of no mean order. But they were anaemic, they felt the cold more than fellow students, demanded excessive bedclothes even though sleeping in a centrally heated bedroom, were disinclined to patronize the warmed indoor swimming bath, cut down involuntarily the amount they walked and *could not keep their minds off food*.[2] This does not suggest that a Calorie intake of 2000 per day is satisfactory for American college students who to some extent could regulate their extra activities. Much less does it suggest that 2000 is enough for the average man who has to perform muscular work to schedule.

It is true that the League of Nations Technical Commission assessed the minimal figure for male *and* female at 2100 Calories, but the male's need was subject to various additions to compensate

[1] Quoted from MARRACK, *Op. cit.* 157.

[2] MARRACK, *Op. cit.* 42. Squad A's haemoglobin level after 2 months of the diet lay between 70 and 80 Sahli (81 to 93.5 Haldane). Squad B's fell in 22 days from 87 to 81 (Sahli).

energy output of the basal metabolism and for 8 hours being ' up and about " = 747 Therefore, while doing mechanical work equivalent to 235 Calories the body must expend

$$940 + 747 = 1687,$$

which accounts for the third item in our sum

This figure of 3000 Calories represents the theoretical daily output of a man doing eight hours' moderate physical work per day and corresponds with considerable nicety with the average intake as discovered in numerous investigations If we add 10 per cent to account for the loss in digestion and utilization of food, we see that the edible portion of the food should represent approximately 3300 Calories

It is indeed tempting to measure the Calorie output by means of gaseous exchange of people engaged in various avocations and activities to add up throughout the day the Calorie output during these activities and then to state that the food requirements for such and such people should yield Calories to that total plus 10 per cent to allow for inevitable losses

Thus, sitting at rest has been measured to need 30 extra Calories per hour dressing and undressing 50 Calories running 500 swimming 550 playing the piano 55, or in the case of playing Liszt s music, 140 Dancing the polka heads the list among the dances Sewing and peeling potatoes demand 40, writing 10–30 carpentry 137–176 sawing wood 400 and coal mining 114 to 205 according to the nature of the work [1] Using such figures we can estimate the theoretical output of anyone if we know his day s activities and thence estimate the Calories he should take as food And doubtless such figures would show some sort of correlation with reality if we accept them *as an average figure only* [2] Thus we might assess the coal miner s work as needing 3500 Calories per day and if we were feeding all the workers in a mine all the time we should be wise to see that the average Calorie value of the diet fed reached a level of 3500 + 10 per cent = 3850 Calories per day It would be foolish to insist that everyone engaged in mining took his 3850 Calories that one who took less was under eating and that one whose intake was near the 5000 level was greedy Figures will be given later to show how absurd such an attitude would be

[1] Figures collected by J R MARRACK (1942) *Food and Planning* Gollancz London 35 36

[2] Interesting examples of such calculations are given by MARRACK *Op cit* 36 39

seems to be some self-regulating mechanism at [illegible] effect. It is true [illegible] of the amount necessary. As Dr. [illegible] Marrack and others have pointed out, many people remain constant in body weight for periods of 20 and 30 years as the result of this self-regulating mechanism, and it is Calorie intake which largely governs body weight. And as this mechanism, when all works well, [illegible] supply and ability to purchase food, seems to give a value around [illegible] Calories per day as the figure of choice, we may accept it, for the present, as the desirable though perhaps marginal average figure for the adult male doing light work.

That this figure may be expected to increase on the average with the intensity of the physical work done is obvious, and there are many results obtained which indicate that this is true. We quote figures from previous editions of this book and later figures collected by Marrack.[1]

Other figures are

U.S. Army Ration	[illegible]
Hostels for Munition Workers (1917)	[illegible]
American professional men	3325
Labourer's family, Edinburgh	[illegible]
German soldiers, war feeding	[illegible]
Fully fed tailors, England	[illegible]
Miners and their families ([illegible])	[illegible]
Rowntree's Family Budgets (pre 1914)	[illegible]
Essex Agricultural Labourers (1925)	[illegible]
St. Andrews Families (1931)	
Professional Classes	[illegible]
Intermediate Classes	[illegible]
Shopkeepers	[illegible]
Skilled workers	[illegible]
Unskilled workers	[illegible]
Unemployed	[illegible]
Cardiff Families (working-class) (1932)	3174
Reading Families " (1932)	2906

It will be observed that on the whole the results are fairly uniform. Where poverty exists (e.g. the Essex Agricultural Labourer 1925 or the unemployed from St. Andrews 1931) there the figures are low and may be regarded as insufficient for health. Where there is a freedom, perhaps hard won, to spend freely on food the figures are somewhat higher than is necessary. Certainly where people are well to-do the Calorie value of the diet rises. None the less the figures in the later researches are not

[1] *Op. cit.*

for activity, raising it somewhat for light work and for moderate work to between 2800 and 3200. Bacharach and Drummond suggest a marginal figure of 3000 Calories for the male and 3500 as an optimal figure. The Ministry of Food during the war of 1939–45 has aimed at 3600 as a gross figure

It is clear that there is no absolute agreement. Nor is this astonishing. We have not yet made up our minds at what we are aiming, nor do we know yet how what we may be aiming at is to be obtained. Do we wish merely to keep people alive, or to obtain the maximal physical efficiency regarding man as a machine from a given amount of Calories or to ensure the "buoyant health," which seems to be the goal of American dietitians? Should we encourage the production of the small wiry person or the giant. is 5 ft 7 in our goal or 6 ft ?

We are not saying this to decry any attempts at fixing the Calorie figure. We are sure that on the whole where people take 3000 Calories or more per day the public health is sounder, the moral higher, the expectation of life longer. The diet of Southern India and Assam yields about 2000 Calories per day, though Northern India has a more generous diet. The expectation of life of a new born child in India is 27 years while that in England is 61[1] One important factor in causing that difference is food. Accounts from enemy occupied Europe tell a similar story. France has been obtaining only 1000 Calories per head per day and the health and morale were appalling[2] In Belgium in 1942 the basic ration was 1230 Calories and as a consequence tuberculosis had increased greatly. In Greece according to Cawadias[3] they 'ceased bothering about tuberculosis,' other diseases being still more rampant. In Great Britain it is notorious that health during 1939–45 has been better than ever before—despite all drawbacks of black out ventilation, overwork and anxiety—and part of this must be due to the fact that we kept the Calories up above the 3000 level though perhaps the main result is due to the better distribution of food particularly the distribution of milk, among the people

Calories matter. Deprivation of calories is starvation. Without water the body dies after a few days. Without Calories it may last some 50 days or even more. Under supply of Calories provokes a continuous hunger when the mind cannot 'keep off the subject of food' In fact if instinct be a guide in the choice of food its clearest effect is in the search for Calories. There

[1] Orr (1943) *Food and the People*, The Pilot Press London, 45

[2] *Lancet* (1943) 2, 703

[3] *Loc cit*

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[1] ORR. (1943) *Food and the People*, The Pilot Press London, 45
[2] *Lancet* (1943) 2, 703
[3] *Loc cit*

seems to be some self-regulating mechanism, often, it is true, overlaid by custom and habit, which guides us in the right choice of the amount necessary. As Du Bois, Marrack and others have pointed out, many people remain constant in body weight for periods of 20 and 30 years as the result of this self-regulating mechanism, and it is Calorie intake which largely governs body weight. And as this mechanism, when allowed to work unfettered by supply and ability to purchase food, seems to set a value around 3000 Calories per day as the figure of choice, we may accept it for the present as the desirable though perhaps marginal average figure for the adult male doing light work.

That this figure may be expected to increase on the average with the intensity of the physical work done is obvious, and there are many results obtained which indicate that this is true. We quote figures from previous editions of this book and later figures collected by Marrack [1].

Other figures are

U.S. Army Ration	3851
Hostels for Munition Workers (1917)	3463
American professional men	3325
Labourer's family, Edinburgh	3228
German soldiers, war footing	3093
Fully fed tailors, England	3053
Miners and their families (1924)	3035
Rowntree's Family Budgets (pre-1914)	3000
Essex Agricultural Labourers (1925)	2872
St Andrews Families (1931)	
Professional Classes	3638
Intermediate Classes	3423
Shopkeepers	3354
Skilled workers	3239
Unskilled workers	2776
Unemployed	2089
Cardiff Families (working-class) (1932)	3174
Reading Families ,, (1932)	2906

It will be observed that on the whole the results are fairly uniform. Where poverty exists (e.g. the Essex Agricultural Labourer 1925, or the unemployed from St Andrews 1931), there the figures are low and may be regarded as insufficient for health. Where there is a freedom, perhaps hard won, to spend freely on food the figures are somewhat higher than is necessary. Certainly where people are well to do the Calorie value of the diet rises. None the less the figures in the later researches are not

[1] *Op. cit.*

far from the 3000 level If we average those from the Medical Research Council's Special Reports from 1917 to 1932 we obtain a figure of 3098 Figures collected by Widdowson [1] give an average of 3067

Turning to figures from people engaged in more strenuous livelihoods and avocations we may quote Lumbermen Main 6995 Miners, Tomsk 6015, Brickmakers, New England 7551, Wrestler, Finland 4 662 Wrestler, U S A 4741 Olympic athletes 4700

Some of these figures were collected by the individual method, *others are averages* *Now when the people are all of an age and* sex—say all adult—no complications are involved in obtaining the average figure But in many of those given above the sexes and ages are mixed, so the figures are suspect because the method of an "index" to represent the "man value" of women and children has been used In fact we know as yet but very little about the Calorie intakes of women and children *as will be shown later* Consequently the coincidence of the average of the British figures with the magical estimate of 3000 must be viewed with suspicion We need to start with individual dietaries collected from men women and children in circumstances in which poverty does not limit choice of food It might be thought that for men and women we had such figures prior to 1935 and we certainly have had some figures for children in New York and New England, which we have quoted above But until the publication of figures for men [1] and women [2] in 1936, and the collection of over 1000 dietaries for children still unpublished as this portion of the book was being prepared we had no data for this country which probe the correspondence of reality with the theoretical treatment usually given to the subject The figures are somewhat shattering to theory

With the men though the average figure was 3067 the variations from that mean are very wide and it is stated by the author that ' the adoption of 3000 Calories as the requirement of an individual man may be most misleading

Perhaps it would be wise to go more closely into these figures and the way in which they were collected We quote from the original article ' The subjects of this investigation were sixty three healthy men of the English middle class and all lived at their homes Their ages ranged from 18 to 89 years Sixty of the subjects were in regular employment the remaining three had retired The occupations which were very varied were mainly of a moderately active kind, though about eight might be

[1] WIDDOWSON (1936) *Journ Hygiene* 36, 269
[2] WIDDOWSON and MCCANCE (1936) *ibid* 36, 293

classed as sedentary and three as very active None of the subjects was judged to earn an income which was too low to provide him with the food he required, so the dietaries could be considered to be freely chosen so far as money was concerned They would all probably fall into Orr's three highest income groups

Each subject was provided with a spring balance weighing by ½ oz up to 1 lb, a plate on which to weigh the food and a form on which to enter results The subjects were interviewed personally in almost every case and the exact procedure to be adopted was explained to them individually A record was taken of their heights and weights

All food eaten during the period of one week was weighed The weighings were carried out on the edible portion of the food, and where bones skins of fruit etc, were included this was stated so that allowance could be made in calculating the results

It will be seen that the people concerned relied on their appetites and instincts to guide choice in the amount of food eaten and its nature There was no stinting or deprivation due to poverty no reason to suppose that anything but inclination led them to eat the foods they did eat and in the quantities they wanted Yet though the mean figure was 3067 one took actually less than the "Sewing girl London, low wage" quoted as an example of under nourishment in earlier editions of this book, viz 1772 while another took more—20 per cent more—than a member of a University boat crew, viz. 4955! Moreover, the highest Calorie inputs are not necessarily those of the most strenuous workers and the widest variation occurs among men of similar occupations The university teacher of 28 years who took 1772 Calories per day was slightly overweight while the man one year older an electrician who achieved the record figure of 4955, had a normal weight for his height and age And these were not freak figures The spread of the individual figures was much that of a probability curve and the standard deviation 714 Calories Reputations in dietetics have been wrecked for less than this

Observations which have been made on diabetic patients of all ages taking insulin show that they can maintain their weight as a rule year in year out, on diets containing C 130–150 grammes, P 70–80 grammes, and F 100 grammes, and yielding Calories 1770–1850 It is rarely that the Calories of the diet have to be raised above 2000 though this is necessary in the young adolescents or in patients with a wasting disease like tuberculosis

Summing up the matter we may say that though the average figure 3067 fits in very well with our theoretical calculations nothing else does Although there can be little doubt that *on the average*

increase of physical work and increased height and weight run parallel with increase of Calorie needs, there is absolutely no ground for rigorously applying this to the individual One man on moderate work may be consuming food appropriate to very hard work and not be putting on weight, another on light work may consume food 25 per cent *below* the League of Nations figure and yet be *putting on weight* *In fact, so far as we have gone in dietetics* it is difficult when dealing with the individual male to see any rhyme or reason in his Calorie intake There must be reasons why one man is pleonectic as regards food and another meionectic, but we do not yet know them It is a disservice to pretend that such variations between individuals do not exist or that we can explain them And such considerations throw grave doubt on the usefulness of the "coefficient" or "index" (see p 40)

Fact and Theory in the Calorie Input in Women We have seen that the Calorie input in men when measured individually shows an enormous variation We have been given evidence that the 'average" man's input is 3000 Calories approximately We have been given the guess that a woman's average input should be on Lusk's and Cathcart and Murray's scales, *0 83 times that* of a male i e 2500 per day

When the input of Calories in women is estimated individually [1] it is found that the spread of inputs is almost as great as that of the men above quoted The lowest figure was 1453 per day, and this was the amount taken by a secretary leading an active life with a body nearly 12 per cent *above* the normal standard weight and height Nine out of the 63 women investigated were leading active lives on intakes of less than 1700 calories per day "Three of these were housewives two were secretaries two were cooks, one a dietitian, and one a student, all people with free access to food Of those on a high input, 2900–3100, two were markedly underweight for their heights, one just slightly overweight and one, a cook 61 per cent overweight Again there is no rhyme or reason in the figures so far as can be seen

The average input of calories was nearly 2200 Calories per day, so that if we place our credit in "coefficients' or "indexes' a woman becomes 0 73 of an adult male, instead of the 0 83 of Graham Lusk and Cathcart and Murray It is true that the latter [2] did find in five individual cases they investigated, a coefficient of 0 7 for the woman but they preferred to calculate the family intake "per man on the old conventional basis of 0 83 Estimates of the

[1] WIDDOWSON and McCANCE (1936) *Journ Hygiene* 36, 293

[2] CATHCART and MURRAY (1931) *Med Res Council Spec Rep Series*, No 151

Caloric input by women University students in the laboratory of one of us give figures usually below the 2400 level of the League of Nations technical committee, i e an index below 0·8 When, however we note that in Widdowson and McCance's figures the index runs from 0·48 to 1·03 in individual women we may wonder if the index has any value whatever except in the minds of those who wish to make dietetics appear more 'scientific' than it is Each individual is a law to him or herself and so long as body-weight and activity appear to be unimpaired we cannot say that such and such a diet, deviating widely from the mean, is wrong or unsuitable

In this discussion we have been in danger of assuming that what people do, on the average, in the way of diet is right If the average male not in want, takes 3000 Calories and the average female in similar circumstances takes 2200 then those figures become in some way right and sacrosanct If there is any truth in the idea that our food habits are instinctive there might be some reason in paying attention to these figures Perhaps there is Introspection does seem to show that so long as one is healthy and leading a healthy existence one's appetite leads one to eat an amount of food, if *simple*, commensurate with one's need On the other hand fashion in woman in the search for a definite silhouette a 'refined" attitude towards food or a desire for attention on the part of solicitous relatives and friends may and frequently does upset the instincts We have no *a priori* reason for assuming that any of the figures obtained by observation upon man or woman are optimal figures We do not know if all these women had taken more food (or even, possibly less) they would not have been in better health All we can say is that each individual diet was apparently 'safe' and not obviously leading to trouble For the present we may accept the figures 3000 and 2200 as respectively satisfactory for the average man and woman while always admitting that the true input for any individual may range far from these means without danger of under or overfeeding

We have here an anomaly which needs scientific investigation We have seen that estimates of basal metabolism do show some uniformity in that the Caloric output per square metre of body surface varies but little from the average in different individuals Anything 10 per cent on either side of the average figure throws doubt upon the health of the person with that variation Yet when we investigate total metabolism we find that each person is a law unto himself He may be 40 per cent below the norm or 60 per cent above it and yet appear perfectly healthy

We must assume that man as a machine for doing physical work

outside that for keeping the machine alive is a most unstandardized piece of machinery, and unpredictable till we know much more of his endocrine, nervous and—dare we breathe it in a work on dietetics—emotional make up It will take much more research upon individuals as individuals before we can resolve this anomaly So far we have shut our eyes to it in spite of the publication by Graham Lusk of curves representing the Calorie intakes of three boys of different types as in Fig 4

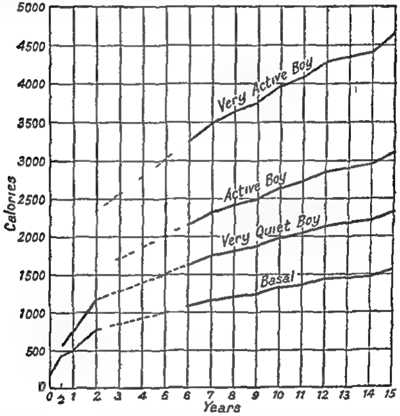


FIG 4 —CALORIE INTAKE OF BOYS OF DIFFERENT ACTIVITIES

Theory and Fact in the Calorie Input in Children In view of the discussion we have had above concerning the index for children and adolescents it may come as a shock and surprise that these indexes are based on little experimental work So far as is known with the exception of the figures of Holt and Fales already quoted there have been published no consistent observations for any large number of individual children

Figures have been collected in this country of the inputs of over 1000 middle class children of all ages up to 18 by the indi

vidual method in the years immediately preceding the outbreak of the war of 1939–45 They are as yet unpublished A preliminary account of the findings was given by McCance and Widdowson at a meeting of the Nutrition Society of Great Britain in the spring of 1944 They are sufficient to show that it is impossible to apply the index method of estimating Calorie needs to individual children At any age we may find a child taking twice the amount of Calories (and also protein, etc) of another child in that group We give with the permission of the authors of this unpublished work and with all reservations of a scientific nature the *average* Calorie inputs at each age investigated side by side with those of Holt and Fales[1] the League of Nations Technical Commission and the National Research Council, U.S.A

Age	McCance and Widdowson		Holt and Fales		League of Nations			National Research Council U.S.A.	
	Boys	Girls	Boys	Girls	Boys and Girls	Boys	Girls (with allowance for activity)	Boys	Girls
1	1154	11[illegible]2	[illegible]0	940	840			1200	
2	1406	1431	1135	1110	1000			1200	
3	1691	1[illegible]33	1275	1230	1200			1200	
4	1839	1[illegible]18	1350	1300	1200			1600	
5	1732	1[illegible]08	1490	1410	1400	2040		1600	
6	1940	198[illegible]	1600	1520	1400	2040		1600	
7	2178	199[illegible]	1[illegible]4	1660	1650	2250		2000	
8	2170	2085	1920	181[illegible]	1690	2290		2000	
[illegible]	2443	216[illegible]	2110	1990	1920	2[illegible]20		2000	
10	2[illegible]01	234[illegible]	2330	219[illegible]	1920	2520		2500	
11	2[illegible]21	2292	2[illegible]10	2[illegible]20	2160	2760 or more[2]	2700	2500	
12	2630	2370	273[illegible]	2860	2400	3000 or more[2]	3000	2[illegible]00	
13	27[illegible]6	2[illegible]00	3010	3210	2400			3200	2800
14	300[illegible]	2637	3400	3300	2400			3200	2800
15	3400	2[illegible]88	38[illegible]	3235	2400			3200	2800
16	310[illegible]	2303	4090	3160	2400			3800	2400
17	3223	2[illegible]16	394[illegible]	3060	2400			3800	2400
18	3427	2[illegible]13	3730	29[illegible]0	2400			3800	2400

[1] HOLT and FALES (1921) *Amer Journ Dis Child* 11, 1
[2] Or more according to activity

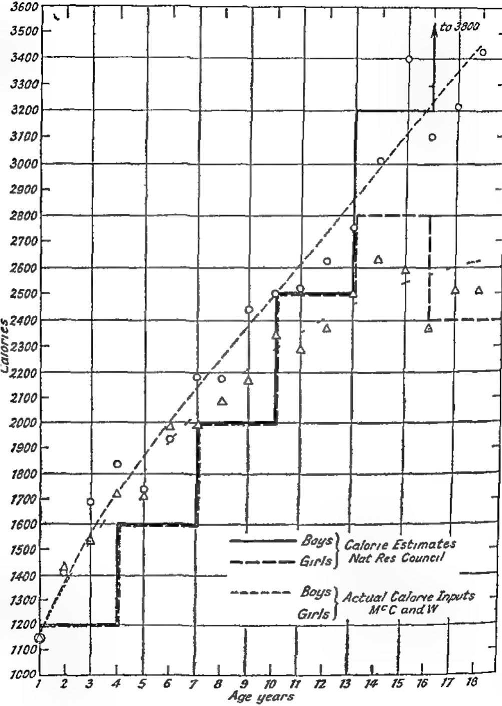

Calories
Age years
to 3800
Boys } Calorie Estimates
Girls } Nat Res Council
Boys } Actual Calorie Inputs
Girls } McC and W

FIG 5

A graph plotting the McCance and Widdowson figures against the American estimates is also given

Before commenting on these tables we may note (i) McCance and Widdowson's and Holt and Fales' figures are based on actual measurements of Calorie inputs in educated middle-class children, the former are based on over a thousand observations, the latter on but 100 (ii) Holt and Fales' figures are "smoothed" while those of McCance and Widdowson are not (iii) The League of Nations and the National Research Council's figures are estimates only (i e guesses based upon past observations, but still guesses) of what children should take

We see that compared with American children English children do their eating young They outstrip Americans by at least 200 Calories–400 Calories per day (no mean amount) at each age up to 10 If the English figures are an accurate measure of needs and not due either to greed or maternal solicitude children fed on the League of Nations scale up to the age of 5 would be somewhat starved and on the American scale hungry up till 10 years of age

It will be noted that an English girl of 10 is already eating as much as her mother and at 18 is still at a high level—i e above the League of Nations' and the National Research Council's figures

On the other hand adolescence in the boys does not call for such high figures as Holt and Fales and the National Research Council suggest Thus English boys do not reach the 4000 level of Holt and Fales or the 3800 level of the National Research Council and are well behind the still higher figures for American boarding school adolescents given by Gephart[1] Observations by one of us gave the input of 14 English boarding school boys ranging in age from 14 years 4 months to 18 years 7 months average age 16 years 5 months as 3300 Calories a close agreement with the average figure for the same ages of McCance and Widdowson Although we do not admit that the practice of a section of the public albeit an educated and well to do section is a guarantee of rightness—an assumption often too lightly made—we consider these average figures of McCance and Widdowson a saner standard by which to judge the Calorie input of children than any hitherto published. Even so they must be applied in no Procrustean way to the individual child

SUMMARY We have seen in this long chapter that food can be considered from the point of view of its chemical nature or of its use in the body The first important function of food is to supply energy to the body which can be used either in maintaining the

[1] GEPHART (1917) *Boston Med Surg Journ* 176, 17

temperature of the body or conversion into mechanical or chemical (or even electrical) work All can be measured in terms of heat The chief sources of energy in the food are the fats and carbo hydrates, though proteins can be and are utilized in the same way The energy output of the body can be measured either by direct calorimetry or by indirect via gaseous exchange The input can be estimated by investigation of the diet and calculation from food analysis tables Intake equals output in experiments made to investigate this Consequently to measure approximately the out put of a person we may make an inventory and analysis of his diet and calculate his input from food tables When this is done it is found that for the average man the daily figure is 3000 Calories for the edible portion of his food or 2700 for intake Consequently we say that the average man's Calorie needs per day is 3000

To compare families one with another a convention has been adopted *that each child and each woman has a need for Calories* which is some definite fraction of an adult male's need To a woman and to each child according to age and sex a "man value" "coefficient," or "index" is given It is assumed that from these can be calculated the Calorie needs of any family When, however, we turn to facts we find that there is no correspondence between theory and fact for the individual and the "index" belongs to mythology Man's Calorie intake may vary from 1700 to 5000 per day without obvious cause A woman's may vary from 1400 to 3000 (average figure 2200) again without obvious cause There are figures for British children in the course of publication and preliminary reports show that there is the same spread of the figures The actual Calorie needs of a given family cannot be predicted and their Calorie input can be usefully gauged only by direct observations on each member of that family as an individual (See also p 263 *et seq* and 522–3 Pregnancy)

CHAPTER III

THE FUNCTIONS OF FOOD (*continued*) (II) SUPPLY OF BODY-BUILDING MATERIAL

During childhood the body grows, adding constantly to its substance, till it has reached adult stature Even then some parts continue growing—e g the skin hair, and mucous membranes of the alimentary tract Moreover parts wear out and are replaced Or they may be damaged by accident—e g a piece of skin torn away—and have to be repaired If a particular organ be over exercised it may respond by hypertrophy, i e by increase of its substance In other words it grows

All such growth and repair of the wear and tear of the body need a particular type of material in the food the *proteins* Most foods contain some protein but for the purposes of practical dietetics only foods with a considerable proportion of these proteins in them are satisfactory for body building purposes

The reason is this all living things contain proteins in their living and even in their dead parts such as nails and hair Protoplasm, the physical basis of life, has protein as its main solid constituent We believe that life as we know it is impossible without protein Plants can synthesize the fundamental units—amino-acids—from which proteins are built up, from carbon dioxide water, and ammonia nitrites or nitrates, but animals cannot do this Consequently animals must prey upon plants or upon animals which have preyed upon plants to obtain their proteins A sound dietetics must always be based upon a sound agriculture a fact now beginning to be dimly perceived by politicians

Proteins possess huge molecules weighing anything from 35 000 to 210 000 times the weight of an atom of hydrogen These molecules are built up from units called amino acids which link up with one another through the amino group uniting with an acid group Amino-acids are all of the type

$$\begin{array}{c}NH_2CHCOOH\\ |\\ R\end{array}$$

where R is some simple linkage of carbon and hydrogen with possibly an amino group or sulphur Two amino acids can link up as in the equation

$$\underset{R_1}{NH_2CHCOOH} + \underset{R_2}{NH_2CHCOOH} = NH_2\underset{R_1}{CH}CONH\underset{R_2}{CH}COOH + H_2O$$

The compound (a dipeptide) can link with another amino acid to form a tripeptide, this with another and so on to make a long chain (polypeptide), and X rays show some proteins to be long chains of amino acids of which the following may represent a middle portion

$$—NH\underset{R_1}{CH}CONH\underset{R_2}{CH}CONH\underset{R_3}{CH}CONH\underset{R_4}{CH}CO—$$

As there are some 22 amino acids available for the building of proteins and there are 250 or more links in the chain of the simpler it will be seen that some or all of the amino acids must be repeated several to many times in the molecule It will also be seen that there is an enormously great possibility of difference between proteins, for the amino acids in a protein may differ in (i) their number, (ii) their nature (iii) their mutual proportions in number, and (iv) their order Each difference will entail a difference in the protein constituted A protein with 200 links would be different from one with 400 links a protein with all the amino acids would differ from one with all but one of the amino acids, a protein with much glutamic acid would differ from one with little, and a protein with the formula

$$NH_2\underset{R_1}{CH}CONH\underset{R_2}{CH}CONH\underset{R_3}{CH}—etc$$

would differ from one with

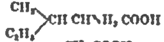
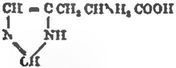
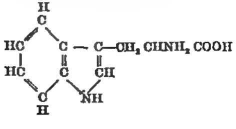
$$NH_2\underset{R_2}{CH}CONH\underset{R_1}{CH}CONH\underset{R_3}{CH}—etc$$

It does not follow that the chains are straight The R_1 R_2, and R_3, etc, may attract each other or repel They may even join up with each other and so on and form girder like structures or frames as of a steel building [1] Most of this is not important in dietetics except perhaps as bearing on the digestibility of certain proteins but what is of importance is that the nature and pro

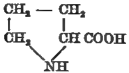
[1] JORDAN LLOYD and AGNES MORE (1938) *Chemistry of the Proteins* 2nd edn Churchill ASTBURY (1941) *Chemistry and Industry* 60 491 says that most proteins are gigantic organized polypeptide chain systems and the chains are in specific configurations and are linked one to another they are polypeptide chain systems heavily disguised

portion of the amino acids in proteins may vary, for herein lies the explanation for some food proteins being preferred to others

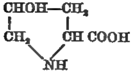
The formulae of most of the amino acids found in protein are here given

Glycine	$CH_2NH_2 \cdot COOH$
d Alanine	$CH_3 \cdot CHNH_2 \cdot COOH$
l-Serine	$CH_2OH \cdot CHNH_2 \cdot COOH$
d Threonine	$CH_3 \cdot CHOH \cdot CHNH_2 \cdot COOH$
d Valine	
l Leucine	
d Isoleucine	
l Aspartic acid	$CH_2 \cdot COOH$ | $CHNH_2 \cdot COOH$
d Glutamic acid	CH_2COOH | $CH_2 \cdot CHNH_2 \cdot COOH$
d Hydroxyglutamic acid	CH_2COOH | $CHOH \cdot CHNH_2 \cdot COOH$
d Arginine	
l Histidine	
d Lysine	$CH_2NH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CHNH_2 \cdot COOH$
l-Cystine	$SCH_2 \cdot CHNH_2 \cdot COOH$ | $SCH_2 \cdot CHNH_2 \cdot COOH$
l Methionine	$CH_3S \cdot CH_2 \cdot CH_2 \cdot CHNH_2 \cdot COOH$
l Phenylalanine	$C_6H_5 \cdot CH_2 \cdot CHNH_2 \cdot COOH$
l Tyrosine	$C_6H_4OH \cdot CH_2CHNH_2COOH$
l Tryptophane	

l Proline



l Hydroxyproline



Some of the amino acids in protein are utterly indispensable in human diet, others can be manufactured by the body if the indispensable ones are given We are fairly sure that the following amino acids are indispensable—this has been proved by experiments on the laboratory rat—tryptophane lysine histidine methionine[1] threonine phenylalanine, and the leucines and we are *certain about phenylalanine or tyrosine and tryptophane in* human nutrition because of the experiments which have been made on human beings on the body building value of gelatin[2] This protein, which is made by boiling tissues of animals which contain much connective tissue (skin, bones, and meat with much tendinous tissue), lacks the amino acids tryptophane valine, and isoleucine and has very little of tyrosine and cystine (many workers say none) Consequently by *itself* it is of no use in building up human or other animal protein This has been abundantly proved from the time of Voit onwards, and for long gelatin though apparently consisting of chains of amino acids linked as they are in protein was denied the name of protein (It was called an albuminoid, a substance like a protein chemically but not physiologically a protein because it could not sustain life The term still lingers on though forty years out of date and either in the form 'albuminoid' or as a protein sparer is a useful danger signal to the intelligent reader)

A similar substance is zein an alcohol soluble protein in maize or Indian corn (*zea mais*) It lacks tryptophane and lysine and though useful in conjunction with other proteins is useless by itself[3 4] The low biological values of gelatin and zein though of extreme interest to the physiologist are of no real importance in dietetics

[1] ROSE in the U S A has shown that methionine is indispensable for man For the work on rats see ROSE (1938) *Physiol Rev* 18, 109

[2] ROBISON (1923) *Bioch Journ* 16 3 gives the bibliography from Voit s investigations up to his own work upon the subject

[3] WILLCOCK and HOPKINS (1906) *Journ Physiol* 35 88

[4] VICKERY and OSBORNE (1928) *Physiol Rev* 8 393

None the less the dietitian must keep the importance of the individual amino-acids in mind and realize that the common plant proteins—the cereal proteins—are relatively deficient in such essential amino acids as lysine, methionine and tryptophane. Indeed there are some who maintain that, instead of discussing minima and optima of proteins attention should be paid to the minima and optima of each indispensable amino-acid. This point of view has been confirmed by discoveries concerning the immense importance of the amino acid methionine in the years 1942–45 for the normal health of the liver and for regenerating damaged liver and skin tissues. When the diet of the laboratory rat is deficient in protein but in no other dietary factor a severe necrosis of the liver cells occurs.[1] If the diet contains very little protein i.e. less than 100 mg. of casein per day, the condition does not occur, presumably because the animal lives on its own tissues, breaking up the muscle protein to obtain the essential amino-acids. But on a diet with between 200 and 500 mg. of casein per day acute necrosis develops. On more than 500 mg. the liver is not affected. The necrosis usually occurring when 200–500 mg. of casein is eaten, can be prevented by adding methionine in the proportion of 8 per cent. of the total protein of the diet. Yeast protein, which contains very little methionine cannot prevent the necrosis even when 1000 mg. are given per day.

We have already noted that methionine is an essential amino-acid in human nutrition and it is noteworthy that outbreaks of massive necrosis of the liver occur among people living on diets grossly deficient in proteins.[2] Further milk has been successfully used in the wars of 1914–18 and 1939–45 to combat the necrosis of the liver due to trinitrotoluene (T.N.T.) poisoning. This milk supplied extra methionine.

For long it has been known that severe burns induce a marked output of nitrogen via the urine. The same is true for fractures, tissue laceration and extensive operations. Croft and Peters[3] have investigated this loss of nitrogen in burnt animals and have shown that increased protein in the diet mitigates this loss and further that extra methionine given in the proportion of 1 per cent. of the total protein works in the same direction. The other amino acids tested, alanine, cysteine and a mixture of synthetic amino acids failed to prevent the loss of nitrogen in the urine. The

[1] GYORGY and GOLDBLATT (1939, 1940 and 1942) *J. Exp. Med.* 70, 185; 72, 1; and 75, 355. HIMSWORTH and GLYNN (1945) *Proc. Roy. Soc. Med.* 38, 101.

[2] HIMSWORTH and GLYNN (1945) *op. cit.*

[3] LANCET (1943) 1, 266.

Martin and Robison showed that it was not necessary to get the body into nitrogenous equilibrium, for the biological value can be calculated *from the slope of a curve relating* the intake and output of nitrogen of the body at stages below the point when equilibrium is reached

Early work by Voit and Korkunoff showed that nitrogenous equilibrium could be reached at a lower level with potato protein than with wheat protein, Rubner and Rose confirmed this observation, Karl Thomas *extended it to a series of food proteins* ranging from those of milk to those of cherries and spinach and including cereals meats shell fish and bony fish Though no one accepts the actual figures he gave (100 for milk proteins, 105 for beef proteins 95 for fish proteins down to 33 for maize proteins) it is admitted that the *order* in which he placed the proteins was right animal proteins at the head of the list, potato and rice proteins nearly as good wheat proteins next and maize somewhat lower on the list

The difficulty of carrying out the estimations on man (see Martin and Robison s account of this) has led to the use of growing of adult rats for this purpose One has to admit that this introduces a doubt in the way of accepting the results may not a protein have a biological value for the rat different from that for man? The doubt is reasonable Man's needs are bound to be different from the rat s but probably similar as regards proteins

The results of all methods have been collected by Boas Fixsen [1] There is very close agreement between them They all put milk and egg proteins at the head of the list (which after all is not astonishing in view of their function), with meat and fish proteins as runners up Next come the cereals followed by the pulses, with the nut proteins bringing up the rear There is some evidence that the cooking of proteins lowers their biological value

The majority of experiments have been made on the mixed *proteins of a food stuff* *Thus the proteins* used have been the mixed proteins of milk and not the individual proteins—lactalbumin caseinogen and lactoglobulin When experiments are made with purified separated proteins it is almost invariably found that the mixed proteins have a higher biological value than either component of the mixture Thus a mixture of lactalbumin and caseinogen gives a better result than either protein separately The glutenin and the gliadin of wheat have low biological values when fed separately but when fed together have a much higher biological value The reason is that gliadin has but little lysine in its molecule while

[1] Boas Fixsen (1935) *Nut Abst and Rev* 4, 447

the glutenin is *relatively* lysine rich Consequently the glutenin can *supplement the effect of gliadin* Similarly gelatine which by itself has no biological value can supplement the effect of wheat proteins because it has thrice as much lysine as glutenin

The bearing of this upon the practice of dietetics is as follows

1 We deal in dietetics with mixed proteins and consequently the biological value of isolated proteins is of theoretical interest only Thus the low biological values of gelatin and zein do not much concern us for no one is going to feed either an abnormal or normal person upon either of those proteins alone Nor on the other hand need we exclude gelatin from a diet because it has a low biological value As we have seen it actually enhances the biological value of wheat proteins[1]

2 We have experimental reasons for advocating a dietary in which the proteins are well mixed

3 We are practically forced into the position of advocating that there should be some food with protein of the highest biological value in the diet every day The function of this protein is two-fold (*a*) it can be used directly for body building with as little expenditure and waste of chemical energy as possible and (*b*) it enhances the biological value of the other proteins in the diet It is difficult to say which is the more important function

It is a dogma among dietitians in which we heartily concur, that it is of great importance to include a measured amount of first-class protein, i e protein of high biological value in the diet of every man woman, and child, and more particularly in the diet of those who are building body tissues or manufacturing proteins children, convalescents from a wasting illness pregnant and nursing women By proteins of high biological value we mean those of animal origin the proteins of milk, eggs meat fish and cheese

Daily Intake of Protein

As dietetics is a quantitative subject two questions at once arise how much should our *total intake of protein* be per day? and how much *first-class protein* should there be? We have to admit that though we can give practical answers which are based on empiricism we have little incontrovertible fact We can say that for a male adult the total intake of protein may reasonably be taken as

[1] Nor it may be urged should we on these grounds extol the strengthening values of jellies and soups for these rarely contain more than 5 per cent of gelatin In fact the physiological merits and demerits of gelatin have received far too much attention in dietetics Its value in diet is mainly culinary and aesthetic

though, as a matter of fact, a diet in which wheaten bread is present in large amounts is a high total protein diet Vegetarianism, and the emotional trends which make some people take up vegetarianism, are on the side of a low protein diet The state of war has proved to many of us that we can subsist on a low protein diet Before this last war a sentimental adulation of the peasant way of life was fashionable, and peasant diet is often a low protein diet [1] Finally—and this consideration seems to us to be important—there is a big gap between the amount of protein necessary to replace the loss due to wear and tear and the amount which is recommended above, viz 70 grammes per day of total protein

Before discussing this serious discrepancy let us assemble a few of the facts known about the minima claimed Nitrogenous equilibrium has been obtained on so low an intake of potato proteins as 25 grammes, of wheat proteins at 60, Martin and Robison put the figure for milk proteins at 38 and wheat proteins at 69 On long extended dietary regimes Chittenden the pioneer of the low protein (and low Calorie) diet showed that his average intake was only 36 though his athletes took amounts which, as Marrack points out [2] were not far from the League of Nations standard. Hindhede maintains that he and his laboratory assistant Madsen remained in nitrogenous equilibrium on as little as 22 grammes per day year in year out though his compatriot Johanne Christiansen will not allow that his experiments are trustworthy Rose whose work seems to be best authenticated lived for 15 years on a diet of 38 to 40 grammes of protein per day and at the age of 70 could walk for 16 hours a day and climb 11 000 feet on a diet containing somewhere about 25–30 grammes It is true that he suffered from numerous colds, but his physical capacity would put most of us to shame

On the other hand, a collaborator Schmid of Thun Switzerland, found that *he* could not live on Rose s 29 grammes per day and considered that it was not possible for *him* to maintain health on less than 60 grammes per day Consonant with this, Susskind, who weighed at the time of the experiment but 52 kilogrammes, found that he could not live on as little as 63 grammes The League of Nations figure 1 gramme per kilogramme was not

[1] This seems to be at the back of Terroine s views quoted below It may reasonably be pointed out that the non peasant agricultural methods of Great Britain prior to 1939 produced more food—much more food—per person employed than in any European country run on peasant cultivation As there is a world shortage of food the less said about peasant cultivation of the soil the better

[2] MARRACK *Food and Planning* 49

enough for him. Corry Mann remained in health when his intake was between [illegible] and 65 grammes of which nearly 42 were animal protein, but failed when he cut down the milk protein even though he replaced it by meat.

What are we to make of this diversity of opinion and experiment? We cannot throw overboard all the low figures by impugning the scientific methods of the observers, nor need we attribute to those of the higher figures psychological instability due to the monotony of the diets they consumed. It may easily be that each person has his own specific level of intake. We know[1] that men in good health and having an income sufficient to meet demands for food take from [illegible] grammes to 107 grammes per day. In these estimates there was to be found little or no correlation between the size of the figures and the weights, ages and activities of the consumers. The protein inputs ran mainly parallel with the Calorie figures: a high protein input nearly always accompanied a high Calorie intake. The frequency distribution diagrams of total protein and of Calories showed considerable likeness. All we can say about such figures is that some people eat more than others without apparent reason and perhaps we may say also of the experiments on protein minima that some people can attain minima unattainable by others. At any rate it should make us very chary of cutting people down to the minima of Chittenden, Hindhede or Röse. In fact some people would go so far as to say that in prescribing a diet for a nation or large group of individuals you should legislate for a maximal intake rather than the minimal, lest some should not reach a subsistence level.

Now is there any explanation of the fact that though the wear and tear loss of protein in the body is at the level of about 18–20 grammes a day, most of us take 60 or 70, or even more protein to replace this amount? The wear and tear loss is due partly to the growth, and subsequent loss, of nails, skin and hair. The skin is continually, though usually imperceptibly, being sloughed off. The alimentary and respiratory tracts desquamate gently. Mucus produced by each tract is lost to the body. Further, such a secretion as adrenaline, which must be manufactured from the tyrosine or phenylalanine of the protein eaten, is oxidized and lost. Some of the creatinine lost in the urine also must come from the breakdown of amino acids in the body. Enzymes also are excreted in urine and fæces. In addition it is usual to imagine that the tissues in their activity wear out and let proteins, especially perhaps nucleoproteins, out into the lymph and blood stream, after which they are broken down into their

[1] WIDDOWSON (1936) *Journ. Hygiene* 36, 269.

component parts and excreted as carbon dioxide, uric acid and urea The wear and tear protein is pictured as the protein which has been built up into the tissues or secretions of the body and as the result of wear and tear has been "rubbed off" those tissues or excreted because no longer wanted This view of wear and tear protein metabolism was developed by Folin and by him dubbed 'Endogenous protein metabolism' The metabolism of any protein (in the form of amino acids) which was not built into the tissues of the body but used for combustion and the production of Calories was termed 'exogenous protein metabolism'

There is apparently a big gap between the figures for the necessary minimum wear and tear protein, i e the endogenous protein metabolism and the total protein metabolism Most of us, though not the Chittendens the Hindhedes and the Roses live a prodigal existence throwing most of the protein we eat on the bonfires of the body to produce energy It is even worse than this Protein has a 'specific dynamic action," as it was termed by Carl Voit, its discoverer

When food is fed to the body in amounts which should theoretically cover the output of Calories the body promptly steps up its output to a still higher level There is a "luxus" consumption on the part of the body—it apparently finds an increase of income irresistible and behaves in a spendthrift manner Now protein has an effect on expenditure of Calories far greater than that due to fats and carbohydrates Whereas these raise the level of expenditure some five per cent above the original level protein may raise it by 30–37 per cent Thus in an experiment by Voit often quoted an amount of protein which on combustion by the body theoretically should yield 100 Calories evoked an outburst of 137 Calories, and Du Bois [1] calculates that at least 30 per cent of the available Calories of a large beefsteak breakfast eaten by himself went in this wasteful specific dynamic action For the heat has to be wasted it cannot be used for muscular energy It is true that it can be used to keep up the body temperature In animals exposed to a temperature approaching freezing point, the specific dynamic of protein is low and only rises to its extreme when the surrounding temperature of the air is tropical But man everywhere contrives by clothing and housing even within the Arctic Circle, to maintain a tropical or subtropical temperature next to his skin consequently protein consumption has nearly its full specific dynamic action, and therefore protein consumption appears to be an extravagance

The cause of this action though investigated for many years

[1] Du Bois (1936) *Basal Metabolism in Health and Disease*

by Graham Lusk and his pupils is still somewhat obscure As said above it is not evident when the temperature of the air surrounding the body is low Nor is it present when protein is used in manufacture of fresh tissue or as Folin would put it for endogenous metabolism It appears only when protein is fed in amounts considerably greater than those needed to replace "wear-and tear" protein In fact it is conceivable that if we took protein in small amounts at frequent intervals throughout the day there would be no specific dynamic action evidenced. It is known from the work of Voit and Graham Lusk and his pupils that it is not the digestion of protein which causes it. Each individual amino acid has its own specific dynamic action and the results are additive The specific dynamic action of a protein is the sum of the actions of each of its contained amino-acids Therefore since the action of glutamic acid is less than that say of alanine the specific dynamic action of a protein with much glutamic acid in its constitution (e g the cereal proteins) is less than that of a protein with a greater proportion of the other amino acids (e g meat proteins)

The case against high protein consumption on these grounds appears to be getting strong All the protein we eat in excess of that necessary to replace wear and tear is apparently tossed on to the bonfires of the body there to provoke an extravagant and useless waste of heat not only by the combustion of its component amino acids but of fat and carbohydrate as well We leave out of this indictment of high protein consumption all the supposed and largely imaginary evidence that a high protein diet damages the kidneys or produces a high blood pressure The Eskimo eating five times the amount of protein that the American of European origin eats has no greater kidney or arterial blood pressure troubles Nor has the Masai with his diet of meat milk and blood Besides, as Marrack[1] very reasonably points out, why should we have special solicitude for the kidneys? Why not for the heart and therefore prescribe no exercise, or for the brain and prescribe no thought? Moreover man ancestral man in the million years before the dawn of civilization must have lived on a diet predominatingly protein and we are here to tell the tale

There is a case against a high level consumption of protein if Folin's conception of exogenous and endogenous metabolism of protein be accepted But is Folin's conception sound? We have assumed for years that the amino acids arising from the digestion of protein were used in one of two ways (1) they are destroyed at once in the liver, the nitrogen excreted as urea and the fatty acid or the glucose formed from the residue used for fuel (exogenous

[1] MARRACK. *Op cit* 49

nitrogen metabolism), or (ii) they are built by the body into human protein[1] So many molecules of alanine, of phenylalanine, of lysine and so on are taken from the circulating blood, are placed end to end in their right order and riveted together and lo! the miracle of human protein When in the course of time owing to "wear and tear," this protein is no longer serviceable, it is disintegrated into its component amino acids and these in turn are converted into glucose or fatty acid and ammonia by the liver and the end products lost to the body as carbon dioxide and urea Some amino acids built up into nucleo protein do not reappear in the form in which they were used in the process of building, but take a different path and appear as uric acid This process of the building of amino acids into the proteins of the body's tissues and the subsequent disintegration of their constructions we termed "endogenous protein metabolism" This is the doctrine we have been wont to teach to our pupils for the last forty years It is wrong

Suspicions of the doctrine had been aroused by the fact that when the protein intake by the body (human or animal) is reduced to zero the nitrogen output in the urine does not at once fall to the lowest level accepted as 'endogenous", nor, again does the output at once rise to the 'exogenous' plus "endogenous" level when the intake is raised from zero to a normal figure There may be a lag of four or five days before constancy is reached It appears as if the body were reluctant to part with some nitrogenous material not truly "wear and tear" protein when placed in protein starvation and also as if, when again raised from zero to normal intake, it makes a point of restoring those reserves before excreting the same amount of nitrogenous material as it is receiving Of course the explanation of sheer inertia could be given of these phenomena, but such explanation did not wholly quieten suspicions that the explanation lay deeper The discovery of isotopes by Aston and the subsequent isolation in quantities of these isotopes of elements has put a means of investigation into the hands of experimental biologists which has thrown much light upon what is happening in the body in the process of protein metabolism The result is that whereas the terms exogenous and endogenous metabolism are still useful terms the distinction between them, once held to be so sharp is very tenuous[2]

It is clear that if you give an animal an amino acid say leucine,

[1] Small amounts are needed for the manufacture of enzymes and of hormones such as thyroxine adrenaline secretin and insulin

[2] SCHOENHEIMER (1942) *The Dynamic State of Body Constituents* Harvard University Press

to eat with its normal diet you cannot discover whether that leucine is metabolized at once or if it is built up into the protein molecules of the tissues of the body It might go via the exogenous path or it might replace a leucine in say, the serum or the heart or even the skin proteins No one could tell But if it could be labelled in some way which would enable it to be identified, then we could track it down and discover if it were changed at once into urea or built up into tissue protein We should expect that if it were given in addition to a satisfactory protein diet one that much more than covered the needs for replacement of wear and tear of the proteins it would be metabolized and excreted at once as urea i e it would follow the exogenous path of protein meta bolism, at any rate in the main

Schoenheimer[1] and his associates have accomplished this label ling by inserting heavy nitrogen (N^{15}) into the amino group of amino acids and by replacing the hydrogen either of the amino-groups or of the carboxylic group with heavy hydrogen (deuterium) Feeding such amino acids to an animal enables the observer to discover whether they are built into the protein molecules or metabolized at once If the latter, the heavy nitrogen and the heavy hydrogen which had been inserted into the amino group of the amino-acid would appear in the urea excreted Supposing it is built into the protein of the tissues it can be found there or if endogenously metabolized it could be discovered in part in the allantoin excreted by the animal

In the first place it was found that the animals treat these labelled amino-acids exactly like the normal amino-acids The animal body cannot distinguish between the two One is as useful as the other in metabolism

Secondly when labelled amino acids are fed to the laboratory rat mixed with a high (16 per cent) protein diet the tissues build into their substance 44 per cent (labelled glycine) or 56 per cent (labelled leucine) of the labelled acids Intestines kidney and spleen are the most active tissues which do this and the skin the least Thus instead of at the most 20 per cent of the fed amino acids being concerned with endogenous protein metabolism, at least double and sometimes treble that amount was so concerned Further it was found that amino acids doubly labelled i e in their amino groups and in their carboxylic groups were not built in their entirety into the proteins of the tissues—the *amino groups parted company from their associated carboxylic groups* Labelled leucine fed to an animal might be used in the construction of tissue

[1] For a condensed account of these experiments and a full list of literature on this topic see SCHOENHEIMER *op cit*

protein which on hydrolysis would yield not only labelled leucine but labelled glycine Those results show that the amino acids continuously interchange nitrogen atoms Glutamic and aspartic acids acids appearing abundantly in cereal proteins but less abundantly in animal proteins are the most active in this interchange whereas lysine which occurs to the amount of 6 per cent of human muscle protein and but 1 per cent in the glutelin of wheat flour,[1] is a complete exception It may yield up a labelled amino group to another amino acid but it never accepts one It is the single indispensable chemical unit which has to be supplied as such in the diet

The picture we must build up of protein metabolism is one in which the amino acids in the circulating blood and tissue fluids are being continually exchanged with those forming part of the body tissue *proteins, some in toto (e g lysine) and some as regards* the carbon chain (leucine and histidine) but not as regards the amino groups These, too, may be held to exchange places between the amino acids forming part of the tissue proteins and the circulating amino acids When an animal is in nitrogenous equilibrium *the equilibrium is not a static but a dynamic equilibrium There* is a continual interchange between the circulating amino acids and those composing the proteins of the tissues

In fact endogenous protein metabolism and exogenous protein metabolism fade off the one into the other All the architectural *pictures we have made in the past of amino acids as* Bausteine (building stones) and the proteins of the body as permanent buildings[2] must be abandoned unless we push the conception to an extravaganza in which stones and bricks and chimney pots continuously fly out of passing lorries and exchange places with *similar objects in the houses on the road along which the lorries* are passing

This rapid extensive and even violent interchange between circulating amino acids and those of the tissue proteins is a mark of life and must sink to a lower level of activity if the circulating amino acids are few *At what height should this mark of life be* set ? Clearly the interchange cannot be so rapid if the body is at minimal protein intake The dynamism of the proteins of the tissues is at a low ebb when the circulating amino acids are not being continuously replaced by the products of protein digestion Consequently we have to ask ourselves whether there is any evidence

[1] Quoted by MARRACK. *Food and Planning* 45

[2] See for example the picture evolved by one of us in which different proteins are compared with cathedrals and slum tenements V H MOTTRAM (1938) *Food and the Family* 6th ed Jas Nisbet

that producing this low ebb of tissue metabolism is good for one and all A tentative answer is that while we know that some can carry on (e g Rose) with a low dynamic state of tissue proteins others seem to need a higher level of exchange and that as Sir Robert Hutchison quoted in earlier editions of this book, "In order to have enough it is necessary to have too much" The tragedy is that probably two thirds of the world have not even "enough" Until we have much more convincing evidence of the value of a low protein dietary we may reasonably ask that the protein intake be kept on the average at the level suggested by the National Research Council of the U.S.A, but that no one should look askance at wide departure from that level—up and down—realizing that the dynamic level of amino acid interchange may be set at one point in one person and another in another The least we can say is that the old conceptions of "endogenous" and "exogenous" protein metabolism which were the strongest hypothetical backing for a low protein intake have been shown to be false May not the supposed advantages of low protein intake be allowed to follow them into limbo ?

So far we have been considering the total protein supposed to be necessary for the adult male and have accepted provisionally, the figure of 1 gramme per kilo of body weight, the recommendation of the League of Nations and of the National Research Council of the U.S.A. This figure should be accepted as a standard of reference only the evidence for higher or lower figures being still of doubtful value But we have said nothing about the quantity of first-class proteins, and the Americans omit any such consideration This we consider reasonable in the United States and Canada for on the average people in those countries insist on including so much milk and so many eggs in their diet A poor, rather marginal dietary estimate in the U.S.A calls for 227 eggs a year or nearly 4½ per week a figure much greater than in England especially war time England And the fluid milk consumption per person in the U S A is about double that in England Except among the poor whites of the Southern States there is no need to worry about first class proteins in the U.S.A.

It is not so in Great Britain especially in war time Rationed meat milk eggs cheese and bacon at the best produced only 75 per cent of the low estimate for first class—i e animal—protein which has been adopted in this country In war time all had to make use of the full allowance of dried eggs and milk, or have recourse to fish, game and offal (fresh or tinned) communal or other restaurants or to the black market to achieve an animal protein intake as great as the Ministry of Health recommended in

1933 [1] Before the war, it was essential to have some sort of standard of first class protein intake to measure the dietetic value of the country's diet, even if that standard were based on guess work Now that the war is over it will be still more necessary, if only to ensure that controls and subsidies, introduced to the great benefit of the public health be not withdrawn

The figure accepted by the Ministry of Health in 1933 was 37 grammes of first class protein per day The origin of this mystic figure is probably as follows Carl Voit expressed an opinion that 35 per cent of the total protein consumed should be of animal origin This, Graham Lusk, one of his best known pupils expressed as 5 per cent of the total Calories One of us, under Lusk's influence, brought this figure back to Great Britain and retranslated it into grammes 5 per cent of 3000 Calories = 150 Calories Each gramme of protein can produce 4 1 Calories, 150 — 4 1 = 37 approximately The Ministry of Health pamphlet into which this was incorporated pointed out that the figure was by no means extravagant and to make this point clear the following table is given in which is set out the amount of a food stuff which will give the whole of a day's estimated needs for first class protein

A MAN'S DAILY RATION OF ANIMAL PROTEIN

(Each portion contains 37 grammes)

CHEESE	Cheddar	4⅓ oz
	Dutch	3½
	Little Wilts	4¼
EGGS		5–6
FISH	Cod steak A P	9½ ,,
	steamed E P	5¼ ,,
	Haddock smoked A P	8½
	steamed E P	4⅝
	Herring A P	7⅓
	fried E P	4¼ ,,
	Plaice A P	11½
	fried E P	5¼
	Soft roe fried	4½ ,,
	Sole A P	10
	fried E P	5⅓ ,,
	,, Lemon A P	8½
	fried E P	6¼ ,,
	Sprats	8⅓
	fried E P	4⅝ ,,
MEAT	Bacon back A P	11¼ ,,
	fried	4¼ ,,

[1] *Criticism and Improvement of Diet* (1933) H.M Stat Office

Bacon streaky A P	10 oz.
„ fried	4[illegible] „
Beef corned tinned	4[illegible]
sirloin roast E P	3[illegible]
steak lean raw	5[illegible] „
„ stewed E P	3[illegible]
„ grilled E P	4[illegible] „
Chicken A P	8[illegible] „
„ roast E P	3[illegible] „
Ham smoked A P	9
Liver, calf A P	6[illegible]
fried	3[illegible] „
Mutton leg A P	6[illegible] „
boiled E P	4
„ roast E P	4[illegible]
Pork leg A P	7[illegible]
roast E P	4[illegible] „
Milk.	1 quart

These figures in view of war time's rations look perhaps large but compared with the middle class diet in peace time, they are not so imposing. All dietitians agree on the need for a pint of milk a day for everyone and the Ministry of Food has supplied this for all pregnant and nursing women and all children up to five. That is half the day's ration of first class protein. By the time that a middle class person has had that, plus an egg and two ounces of bacon for breakfast and, say, a grilled herring for lunch (at least [illegible] of the ration), he has had over one ration and the animal protein at dinner in the evening represents a surplus. It is not astonishing to find that the middle class animal protein intake is as high as 55 grammes per day. It was surpassed by that of the Army as long ago as 1937 when it was 64 per day. The taking of less than 37 is nearly, but not quite, the hall mark of poverty, as will be seen on studying the figures in individual and other diets.[1] Taking the individual diets of middle class males collected by Widdowson,[2] which we have already mentioned, we find that only one of the 63 diets investigated had less than 37 grammes per day (30) and at the upper end of the scale one contained the large amount of 121 grammes. (Expressed as uncooked meat, this would represent about 1[illegible] lb. steak, or more than a week's ration in war time!)

[1] McCance, Widdowson and Verdon Roe. (1938) *Journ. Hygiene* 38, 596. Fry and Myers. (1938) *Public Health* 358.
[2] Widdowson. (1936) *Journ. Hygiene* 36, 269.

The average animal protein intake reached the high level of 67 grammes per day

We thus see that the figure of 37 grammes is by no means an unreasonably high figure to prescribe as the minimum advisable Nor was it extravagant of the British Medical Association s Nutrition committee to suggest that the animal protein intake of an unemployed male should be 50 grammes Even if it be held that there is little scientific basis for the figure 37, it is one which on sociological grounds we should like to see everyone enjoying

To sum up this section on the adult male s need for total protein we may say that on the average it may be taken as 1 gramme per kilo body weight though there is evidence that some people can maintain efficiency on less and some apparently seem to need more The reason that most of us do not take protein equivalent to the wear and tear protein loss is possibly because life necessitates a continuous interchange between the amino acids of the circulation and those of the tissues and this dynamic level of interchange varies from person to person In most countries except perhaps Canada the U S A New Zealand and Australia it is necessary to insist that some of this protein be first class protein i e protein of animal origin About half the total protein or approximately 37 grammes of animal protein per day represents a figure below which the first class protein should not fall

Adult Women There is naturally less information concerning the needs of the adult female There is no reason to believe that the needs of the adult non pregnant women are proportionally any higher than those of the adult male In fact as her metabolic plane seems to be lower than the male's it might conceivably be less None the less the League of Nations put the figure at the same in proportion to the body weight as the males viz 1 gramme per kilo body weight and the National Research Council puts it higher viz 60 grammes per 56 kilogrammes or 1 07 grammes per kilo When we turn to the figures collected for this country (in London and its environs) by McCance and Widdowson [1] we find that the average protein intake has a value of 67 3 which is rather more than 1 gramme per kilo body weight and that the spread of the figures is great The maximum (90) is more than three times as great as the minimum (28) First class protein on the average was well above the figure of 37 grammes, viz 46 0 Fifteen out of the 63 women took less than 37 grammes but apart from the one extremely low figure (9) the majority of the low figures were at about the 30 grammes level No one apparently has made any suggestion concerning the minimal amount of first

[1] McCance and Widdowson (1936) *Journ Hygiene* 36, 294

class protein necessary for women If we assume her needs to be 0 83 that of a male the figure would be 30 grammes approximately if 0 7, then 26 grammes Only 2 women out of the 63 fall below the 26 level and only 5 below the 30 grammes level There is little guidance here as to what either the total protein or the first class protein should be but at the most only an indication that middle class women in Great Britain exceed the standards of the League of Nations and the National Research Council and the highly hypothetical standard for first-class protein Looking at the frequency diagrams of protein intake by women we see that they unlike those of the men do not follow the shape of the Calorie intakes but whether this has any significance is uncertain

Pregnant and lactating women theoretically need more total protein and more first class protein than the normal McCance Widdowson and Verdon Roe[1] estimate that the total intake of protein in the later stages of pregnancy should be 90 grammes per day but in the 120 diets they collected they found that only the well to-do classes approached this figure with 80 grammes and the others were by no means so high These figures were collected before the war of 1939–45 It is to be expected that the activities of the Ministry of Food in subsidizing the consumption of milk in pregnancy and lactation will have improved considerably the low intakes found by McCance and his colleagues among the working classes and it is to be hoped that this improvement will continue now that the war is over

The League of Nations put the figure for the first three months of pregnancy at the usual level of 1 gramme per kilo body weight from the fourth to the ninth month 1 5 is suggested and during lactation 2 0 grammes The National Research Council put the figure at 85 grammes per day (i e 1 5 per kilo) for the last half of pregnancy and at 100 (approximately 1 8 per kilo) during lactation[2] Until we know much more of the physiology of pregnancy and lactation we must be content with these figures which represent guesses but perhaps reasonable guesses concerning the amounts of total proteins required in pregnancy and lactation

The Protein Needs of Children Here again we are in as great difficulties in giving even average figures as we were with women There has been little large scale work done to discover the actual intake of foods by children let alone what they ought

[1] McCance Widdowson and Verdon Roe (1938) *Journ Hygiene* 38, 596

[2] Clearly no sudden jump at the fifth month of pregnancy and at full term is intended but a smooth grading from the lower figure to the higher

to take Up till the present we have had to rely on data for 100 children collected by Holt and Fales and published as long ago as 1921 There is however a collection of individual diets of over 1000 children, made in the years before the war, an account of which will be passing through the press at the same time as this edition and to which we have already referred Children show the same spread of protein consumption as they do of Calories At any age we may find a child taking an amount of protein (whether first class or no) double that taken by another child in the same age group. There is in the figures no guidance concerning the necessary intake of any one child at a particular age but perhaps the average figures may be allowed to act as a standard of reference, in this country at any rate They represent what is done on the average by children of educated well to do people with no reason to stint money spent on food and so might reasonably, for the time take the place of the scales based largely on guesswork

Of course one way to study the protein needs of children would be to observe their rates of growth on different amounts of protein in the diet This has been done in a small way in the U S A and apparently on a larger scale in the U S S R[1] And it has been found that with children of $1\frac{5}{12}$ to $1\frac{10}{12}$ years 2 5 grammes of protein per kilo body weight allows of growth only in the warm part of the year 3 5 grammes allows growth in cold weather but not optimal growth The Russians therefore suggest 4 grammes per kilo body weight for children from 1–3 years of age The estimates by the League of Nations Commission and the figures coming from the U S S R are placed side by side in the following table

ESTIMATES	PROTEIN PER KILO BODY WEIGHT	
Age	League of Nations (grammes per kilo)	Russians (grammes per kilo)
1 and 2	3 5	4 0
3	3 0	3 8
4	3 0	3 5
5	2 5	3 2
6	2 5	2 95
7	2 5	2 7
8–12	2 5	2 5
13	2 5	2 6
14	2 5	2 6
15	2 0	2 6
16	2 0	2 5
17	1 5	2 0
18	1 5	<2 0

[1] See LEITCH and DUCKWORTH (1937) *Nut Abs and Reviews* **7**, 257

Looking at the table we observe that the Russians have apparently been more generous except between 8 and 12 than the League of Nations and they have emphasized the need for proteins of the adolescents. This is the time of most vigorous growth and it is theoretically the time when the protein intake should be greatest. It is true that the Americans have put the total protein of children from 13-15 well above that of the male adult and of adolescents still higher (viz. 85 and 100 grammes per day) but they nowhere reach the height of the Russian estimates. This is brought out in the calculations of the total protein intakes on the Russian figures per gramme body weight using Woodbury's and Baldwin and Wood's scales of weights of American boys[1] and as it is more easy to think in terms of total protein than of grammes per kilo body weight they are quoted here side by side with the League of Nations scale the American scale and the actual amounts taken by English children. A graph is also given (Fig. 7)

PROTEIN INTAKES ESTIMATED AND ACTUAL

Age	Weight Boys (kg)	L.o.N. Children	Russian Children	N.R.C. Boys	Actual Boys	N.R.C. Girls	Actual Girls
1	[illegible]	34	39	40	37	40	38
2	12.00	42	48	40	41	40	42
3	14.30	42.9	51.4	40	49	40	46
4	[illegible]	47.6	[illegible]	50	52	50	50
5	17.22	47.1	[illegible]	50	[illegible]	50	49
6	19.9	49.9	69.8	50	[illegible]	50	59
7	22.66	60.7	61.3	60	63	60	60
8	24.9	62.3	62.3	60	60	60	59
9	28.3	70.8	70.8	60	[illegible]	60	62
10	31.1	77.8	77.8	70	73	70	67
11	34.9	87.3	87.3	70	72	70	64
12	37.6	94.0	94.0	70	76	70	[illegible]
13	41.6	104.0	108.0	80	79	80	72
14	47.8	119.5	121.5	85	89	80	77
15	51.4	109.8	136.0	85	100	80	78
16	59.4	118.8	148.5	100	94	75	71
17	62.8	94.2	125.6	100	95	75	73
18	64.8	97.2	129.6	100	97	75	76

[1] LEITCH and DUCKWORTH *Op cit* There are some slight discrepancies between our recalculation of these figures and those given by Leitch and Duckworth, probably due to the interpretations of the scales of weights

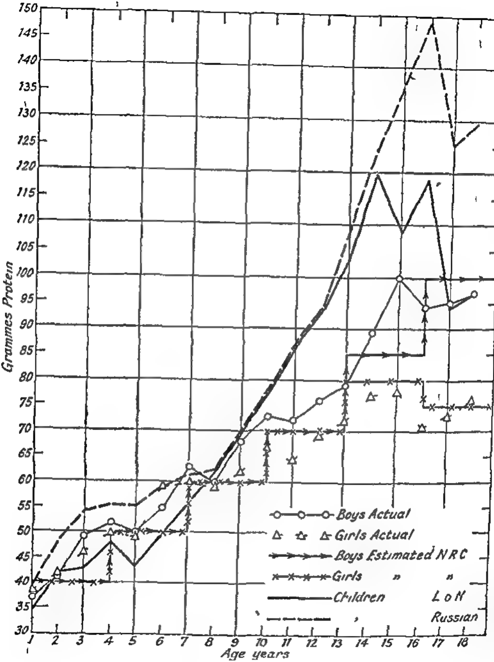


FIG 7

The first thing we notice is that the actual intakes of boys and girls of the well to do classes in this country run very close to the estimates of the National Research Council of the *U S A* whereas

the Russian and League of Nations estimates are much higher from the age of 10 onwards. The average observer cannot but be impressed by the coincidence of the American estimates and the actual findings among English children, and it may remove some of the inferiority complex over against the U.S.A. from which dietitians in this country quite rightly suffer, to realize that the growth of these English children is up to the Woodbury and the Baldwin and Wood standard, and that their diet is as good as American dietitians imagine it should be. In fact it might be argued that we are reaching something fundamental here. When growing children in one country take the amounts of foods considered to be necessary by experts on nutrition in a dietetics-conscious nation like the U.S.A., there is a temptation to say that this correspondence indicates an approach to absolute truth. But scientific caution steps in with the consideration that it may be racial make-up and pattern of life which determine the likeness of the food intake of the two countries. It is true that racially the United States is no longer predominantly Anglo-Saxon nor even Anglo-Celt, and their repertoire of foods is much wider and more interesting than that of Great Britain. None the less, their racial characteristics are predominantly European and their pattern of life more like our own than like other nations.

Turning to minor discrepancies, it will be noted that the intake by boys in this country is *above* the American figures till about the age of 15, and so is the intake by girls until the age of 9. This was to be expected in view of the figures for Calories. With the Anglo-Saxon diet, more particularly middle class diet, it is usually found that the protein intake runs parallel with the Calorie intake. The English child does his eating early in life and therefore takes protein early. Whether there is any more in this than a reflex of parental solicitude it is for future research to show.

The Calories these English children obtained from protein show but a negligible deviation from 12 per cent. of the total Calories all along the scale from 2 years to 18. This, however, does not indicate any inevitable "rightness" of this proportion but is a reflection of the constancy of the nature of the food eaten. We can, however, take the figures for the protein intake after the curves have been smoothed as a standard with which to compare the dietary protein of children in the future. If their intake is up to this standard then we may accept their diet as satisfactory as regards protein, for the growth of these English children is up to the American standard and we have every reason for believing, both from the esteem in which dietetics is held and practised in the U.S.A. and from what we have seen of their manhood during

the war of 1939–45 that America has achieved a sound dietary If, however a child's intake is not up to this standard but there be no reason, such as lethargy pallor or anæmia for assuming that the child is not fit, dietary standards should be forgotten

We have said nothing so far about first class protein for children We have quoted with approval the plea for including some first class protein in the diet of the adult How much more is it necessary for children who are continually adding protein to their bodies ? They are not merely replacing ' wear and tear " losses of protein but manufacturing new human proteins especially in the first year of life and during adolescence Theoretically the growing child (like the convalescent from a wasting illness the pregnant and lactating woman and the athlete in training) should have a higher percentage of animal protein in his total protein intake than the adult who has finished growing Even Terroine [1] who has stated a case against the academic figure of 37 grammes of animal protein admits that children need more first class protein in proportion than adults He claims with some considerable support from experimental data that the biological value of proteins for growth differs from their value for maintenance, and though he pleads for a peasant diet for the adult with only a suspicion of meat and milk to make it palatable he allows the growing child more of the first class proteins Schoenheimer's work on labelled amino acids points out the particular case of lysine [2] which must be presented to the body preformed If we argue from this that that amino acid is indispensable in the manufacture of protein we emphasize the need for animal protein in the young There is 6 6 per cent of lysine in human protein, 7 6 per cent in the chief protein of milk 5 0 per cent in egg protein and only 0 2 and 1 9 per cent in the proteins of wheat Therefore the argument suggests that to manufacture human protein rapidly it is much better to use milk and eggs than wheat proteins In this we completely concur, but the argument can be carried too far [3]

A child puts on 2 or 3 kilogrammes body weight per year until he reaches puberty Let us take the higher figure About [illegible] of

[1] TERROINE (1936) *League of Nations Quarterly Bulletin*

[2] The unique position of lysine among amino acids is brought out by work on its metabolism by NEUBERGER and SANGER (1944) *Biochem Journ* 38 119

[3] A distinct and significant correlation between the increase in weight for height and the input of foods containing animal protein was seen in 120 children belonging to [illegible] families observed by BROCKINGTON (1939) *Public Health* 209

this is water, so the solid material added will be 1 kilogramme. Let us assume that this is all human protein, neglecting the laying down of fat and manufacture of bone. 1000 grammes per year is 2·8 grammes per day. Making the very low estimate of 50 for the biological value of the first class protein eaten we see that the extra first class protein needed per day for growth of the child is on the most extravagant theoretical estimates but 5·6 grammes a day—the protein to be found in less than ¼ of a pint of milk!

In our present state of ignorance about protein metabolism in the young we had better content ourselves with the vague statement that children need more first class protein in proportion than the adult and urge that the efforts of the Ministries of Food, Agriculture, Health and Education, which have resulted in an increased consumption of milk during the war, be continued and further strengthened now that peace is declared. It looks as though the extra needs of children for first class protein for growth can easily be covered by the pint of milk a day which in this country is the goal of dietitians.[1] (In the U.S.A. it is a quart or about 1⅔ English pints.)

Summing up the paragraphs on the protein needs of children we see that *the estimates of different authorities disagree*. Curiously enough the American figures, except at 1 year of age and from 4–6, are the least generous. The Russian figures are the most generous from 1–8 and again during adolescence. Actual data and not mere estimates collected by Widdowson in this country of the diets of over 1000 children give results which on the average closely approximate to the American estimates. They are slightly above at most ages except those of adolescence. It is suggested that until we know much more about metabolism in the young we accept the English figures as our frame of reference in this country, rather than "estimates" by however competent people.

Turning to the needs for first-class protein we see that the theoretical needs of children for extra first class protein for growth when put on a numerical basis are smaller than might be expected and should easily be covered by a pint of milk per day.

Sources of Protein. Before we close this chapter there are a number of practical considerations to be discussed in applying what we know about proteins to dietetics. The first is the source of protein in foods. Very few foods other than sugar and lard and other frying fats are totally devoid of protein. That is obvious

[1] Actually the children of the middle classes in England take on the average two thirds of their protein as first class protein and at most ages far and away more than the "standard" 37 grammes.

are humid Animal proteins have a higher specific dynamic action than vegetable proteins, moreover, most of the sources of animal protein have a fairly high concentration of protein whereas vegetable sources have not Consequently it is easy to have a surplus of protein at a meal when meat is eaten but not so easy when vegetarian foods are used and the specific dynamic action of protein has thus a good chance to show itself when animal protein forms the main part of a meal The difficulty in hot humid climates is to get rid of this inevitable waste heat and so it might plausibly be argued that meat eating be cut down with advantage in such climates but on examination this argument is not unassailable

The lowering of the specific dynamic action of protein in cool surroundings and its raising in warm surroundings was observed in animals Man by his clothing and by his housing accommodation maintains a tropical climate next to his skin Consequently the specific dynamic action of protein will have its full effect whether the shade temperature is high or low None the less it might be well in a hot humid climate to reduce the protein to the minimum necessary and to spread it throughout the day, and not to take it all at one meal If however the nights are cool in a hot climate the concentration of the protein into the evening meal would not matter so much for the specific dynamic action would not be in evidence till 3 to 6 hours later To have however a large protein meal at midday would involve an outburst of heat in the late afternoon at a time when the thermometer is at its highest

In view of the fact that proteins supply but about 10–12 per cent of the Calories of a diet it might seem that the suggestions in the last paragraph are pushing hypothesis too far Thus if all the protein of the day's diet were taken at 8 p m its maximum specific dynamic action (37 per cent) would entail a surplus production of 152 Calories This would probably be evolved from the body between 11 p m and 2 a m i e at the rate of 50 extra Calories per hour As the normal rate when resting will be above the basal metabolic rate of 70 Calories per hour and below 125 per hour (3000 — 24) the extra Calories due to the specific dynamic action of the protein would cause an increase in the rate of evolution of heat by 40 to 70 per cent This certainly is a large increase and where there is difficulty in eliminating excess of heat i e where the nights are hot and humid experience may prove that a heavy protein meal in the evening is unadvisable It must be admitted that custom in the hot humid climate known to one of us flouts theory

Summary As proteins are the main architectural element in living protoplasm and as the body cannot synthesize proteins

from simple inorganic substances, proteins are essential in diet for growth and repair of the body. Proteins are complex chains—condensation products—of simpler organic compounds, amino acids, of which there are twenty or more examples in most proteins. There may be 250 molecules of amino-acids in any protein and therefore some of them must be repeated more than once, indeed many times. Proteins differ from one another according to the number, nature, proportion and arrangement of their constituent amino-acid. Some food proteins are better body builders than others because the amino acids composing them are like those of the human tissues in number, nature and proportion. (Arrangement does not matter because before they are used by the body they are digested to their component amino acids.) Such proteins are said to have a high biological value, and the proteins with high biological value are those of milk, eggs, meat, fish and cheese.

It is therefore considered wise to have some proteins of high biological value in the diet every day. How much is uncertain, but there is a provisional estimate for the adult male of 37 grammes per day. Many did not reach this level during the war 1939–45. How much the total protein should be is also uncertain. Again provisionally it is fixed at 1 gramme per kilo body weight. In practice there are large departures from this suggestion without any disease.

Pregnant and nursing women need more protein than the non-pregnant. The League of Nations estimate is to increase it by one-half in the later days of pregnancy and by 100 per cent during lactation. American estimates are lower. In practice this is rarely achieved.

Proportionally to their weight children need more protein than adults and theoretically more first class protein. The estimates given by different groups of dietitians differ markedly from one another, the Russian figures being greatest during the first few years of life and during adolescence. Until the third decade of this century no one has collected data of children's intakes on any large scale and the results prove disconcertingly variable. The average figures for the protein per day collected by McCance and Widdowson are suggested as a scale of reference for children in Great Britain.

CHAPTER IV

THE FUNCTIONS OF FOOD (*continued*) (III) THE SUPPLY OF ELEMENTS OTHER THAN CARBON, HYDROGEN, OXYGEN AND NITROGEN

So far we have dealt mainly with substances in food usually studied by organic chemists—the proteins fats, and carbohydrates It is necessary now to turn to the supply of the elements usually studied by inorganic chemists They are often referred to as the mineral constituents or mineral salts in the diet This is wrong Sulphur, for example enters the blood stream as part of an amino acid Sulphur in the form of mineral salts is absorbed with difficulty and excreted unchanged The cumbrous phrase of the title shows what is meant, but for practical purposes we shall call them mineral or ash elements

We can best realize their importance by reference to the amounts of these elements which enter into the structure of the body The calculations here given are from analyses by Sherman [1] The following amounts of inorganic materials are found in the body of an adult man of 70 kilogrammes weight (= 11 stone approx)

Calcium	1050 grammes	Cobalt	a trace
Phosphorus	700 ,,	Silicon	
Potassium	245	Aluminium	mere traces
Sulphur	175 ,	Arsenic	
Chlorine	105	Boron	
Sodium	105 ,	Copper	
Magnesium	35	Fluorine	
Iron	2 8	Nickel	
Manganese	0 21	Zinc	
Iodine	0 028		

It will be seen from this table that at least 19 elements enter into the composition of the body though in very different amounts It must not be thought however that the order of magnitude indicates either the order of their importance or gives a complete clue to the

[1] R H A and VIOLET PLIMMER (1938) *Food Health and Vitamins* 8th edn McCOLLUM and associates in *The Newer Knowledge of Nutrition* 5th edn put the figure for calcium at 1400 to 2000 grammes

amount necessary in the daily diet For example, there is much more potassium in the body than sodium, yet we need a much greater intake of sodium than of potassium per day There is but a small amount of iodine in the body, a trace of cobalt and mere traces of copper and zinc Without the iodine life would be impossible and there is more than a hint that the "mere traces" of copper and cobalt are essential in the manufacture of hæmoglobin the red colouring matter of the blood, and of zinc, in the manufacture of insulin and of carbonic anhydrase It is possible that we could dispense with the traces of aluminium, arsenic boron, and silicon though this is by no means proved Fluorine in minute amounts makes for hard enamel in the teeth

The functions of these elements are twofold They enter into the structure of the body and they aid in catalysing the reactions of the living body Thus the spectacular amounts of calcium and phosphorus given in the table go to make up the solid structure of the bones and teeth which account for one fifth of the weight of the body Iron is an integral part of the colour bearing nucleus of the hæmoglobin Phosphorus also enters into the structure of the nuclei of all the cells in the body and into the myelin sheaths of the nerves Sulphur is present in practically every protein and more particularly in those of the skin Potassium is an essential part of the cellular elements of the body, e g the red blood corpuscles though there it is probably held in solution and the functions of the blood corpuscles depend partly on their ability to keep potassium inside them and sodium out Magnesium enters into the composition of the bones and the muscles and the other soft tissues of the body contain magnesium in greater proportion than they contain calcium Animals deprived of magnesium suffer from lesions of the bloodvessels and nervous system and a shortage in the diet leads to defective bones and teeth

These elements may be used for catalytic as well as for structural purposes Thus traces of ionized calcium salts are essential for the maintenance of the activity of the skeletal cardiac and unstriped muscles of the body So essential is the maintenance of the correct amount in the blood (about 8–10 milligrammes per 100 c c) that a set of four glands the parathyroids have that function deputed to them Should there not be sufficient in the food to keep that quantity normal these glands mobilize calcium from the bones to tide over the emergency, and if the deficit of calcium is long continued a condition of tetany supervenes If the calcium in the blood serum falls below 4 or 5 milligrammes per 100 c c tetany may develop and this is especially likely if the ionizable calcium is reduced Phosphorus, as phosphates or pyrophosphate, in

combination with thiamine and nicotinamide, acts as a catalyst in carbohydrate metabolism and is essential in combination with creatine in initiating muscle contraction In fact, wherever there is active metabolism in progress the presence of phosphorus as a catalyst is suspected As a phosphate it is utilized in buffering i e modifying the hydrogen ion concentration of the plasma of the blood and of the red corpuscles Also it is utilized in the secretion of an acid urine from an alkaline blood plasma Sulphur in glutathione is important in catalysing oxidation in the tissues Copper catalyses the manufacture of hæmoglobin and possibly manganese and cobalt aid in this or similar processes Four iodine atoms are present in thyroxine, a secretion of the thyroid gland, which catalyses the metabolic processes of the body Thus 5 milligrammes of thyroxine, containing about 3 6 milligrammes of iodine, injected into the body raise the basal metabolic rate by 40 per cent Zi as we have said, may be essential in formation of insulin t internal secretion of the pancreas which catalyses carbohydra metabolism Zinc also is a constituent of anhydrase an enzyn essential in respiration found in the red blood corpuscles

These facts illustrate the enormous importance of obtaining sufficiency of the various mineral elements in the diet We mu proceed to give an account of the sources of these elements in tl food and the amounts of each necessary in the daily diet

The elements to be considered are the metals calc um magnesiur potassium sodium iron cobalt manganese copper and zinc ar the non metals fluorine chlorine iodine sulphur and phosphoru Some are needed in large amounts and some only in traces, when they get the name trace elements Among these ' tra elements are cobalt, manganese copper zinc fluorine and iodin Convenience and not chemical order has dictated the preceden of these substances in the sequel

Calcium

This element enters into the composition of bones and teeth a the phosphate and carbonate There is evidence that these tw compounds are associated as they are in the mineral apatite I is absorbed probably in inorganic form in the small intestin and this absorption is aided by the presence of vitamin D i the diet How the vitamin works is obscure It is known that th hydrogen ion concentration of the contents of the small intestin increases in the presence of vitamin D and this has led to the sup position that to increase the acidity in that organ is the functio of that vitamin Calcium salts are much more soluble in aci

media than in alkaline But that cannot be the only explanation for calcium in the presence of vitamin D is well absorbed even when the small intestine is rendered alkaline by large doses of alkali[1] The calcium circulates in the blood, in the plasma of which it is present to the amount of about 10 milligrammes per 100 c c , and is presumably deposited in the bone and the excess excreted in the urine The traditional belief that excess of absorbed calcium over the needs of the body is re excreted into the colon is almost certainly false[2] All calcium in the fæces is calcium which has failed to be absorbed or has passed into the gut in the digestive juices Anything which hurries the food along the intestine such as purgation or the use of large quantities of roughage is inimical to the absorption of calcium Meulengracht[3] has described a case of severe depletion of the calcium of the bones (osteoporosis) which he thought was the result of prolonged daily purgation with sulphates Phytates which form insoluble salts with calcium prevent the absorption of that element[4] Excess of phosphates and unabsorbed fatty acids as in cœliac disease chronic pancreatitis, sprue and the inborn error of metabolism congenital steatorrhœa, work in that way If calcium in the food is in the form of a phytate (calcium magnesium inositol hexaphosphate) it will not be absorbed Calcium oxalate (e g in spinach) is not absorbed[5] While 90–100 per cent of the calcium of skim milk, and from 80–100 per cent of that in green leaves of the cabbage and its allies is absorbed only 15–20 per cent of that of spinach is available[5,6]

To ensure absorption the diet must contain available calcium such as that in milk and cheese, and vitamin D must also be present A low calcium diet is of more use to the body in the presence of vitamin D than a high calcium intake in the absence of that vitamin

The lack of calcium in the diet leads to osteoporosis of the bones and the lack of vitamin D to rickets and to osteomalacia which is almost certainly adult rickets The power of forming new bone is not confined to the young According to Roholm, quoted by Leitch[7] workers who have been forced to leave their employment in a cryolite factory on account of deposition of calcium around the bone show the deposits well organized as normal bone when

[1] GRAHAM and OAKLEY (1938) *Arch Dis Child* I N S p 1
[2] MCCANCE and WIDDOWSON (1939) *Biochem Journ* 33 523
[3] *Lancet* (1938) 2 774
[4] MCCANCE and WIDDOWSON (1942) *Journ Physiol* 101 304
[5] FAIRBANKS and MITCHELL (1938) *Journ Nutrit* 16 79
[6] KUNG YEH and ADOLPH (1938) *Chin Journ Physiol* 13 307
[7] LEITCH *Nut Abs and Rev* (1937) 6 553

examined post-mortem years later. Meulengracht and Meyer, also quoted by Leitch give examples of men and women verging on old age who were able to manufacture new bone on treatment with calcium and vitamin D. They had suffered for years with "rheumatic pains" which did not yield to treatment till osteomalacia was diagnosed and they were treated for that complaint. It is possible that the fragility of the bones of the aged and some of their "rheumatism" are due to a prolonged deficit in the diet of calcium.[1] The condition called senile or spinal osteoporosis in which the vertebræ contain much less calcium than usual and are liable to undergo crush fractures, has a different pathology from osteomalacia since there is no osteoid material present.[2] It cannot therefore be caused by lack of vitamin D and its causation is still unknown though it seems probable that a long continued lack of calcium, phosphorus and perhaps vitamin C may be responsible. The final report of the League of Nations Technical Commission on nutrition calls attention to the disappearance of such pains in pregnant women on treatment with calcium and vitamin D. Maxwell,[3] late Professor of Obstetrics and Gynæcology in the University of Peiping often had to perform Cæsarean section on women with osteomalacia resulting from lack of calcium and vitamin D in the diet. The babies of these patients also suffered from fœtal rickets. He thought that the intense activity of the fœtus in utero in such women was the result of a tetany due to lack of calcium and vitamin D. The diet of the Chinese is notoriously deficient in calcium. Though European diet is better supplied there is evidence of a deficit. We have as proof the surveys by Orr[4] and Crawford and Broadley[5] and the fact that Stettner[6] finds a very high percentage of the children of the hospital class with osteoporotic bones at all ages with a minimum at [illegible] years of age, and that osteoporosis also occurs in middle class children. Calculations by the students of one of us showed that in war time and upon war rations it was possible by careful purchase of calcium containing

[1] LYALL (1944) *Proc Nutr Soc* 1 143

[2] BURROWS and GRAHAM (1945) *Quart J Med* N S 14 147

[3] MAXWELL (1923) *China Med Journ* 37 625 (1924–5) *Proc Roy Soc Med* 18, 48 (1925) *Journ Ost and Gynæc Brit Emp* 32 433 MAXWELL and TURNBULL (1930) *Journ Path* 33 327 (1935) *Proc Roy Soc Med* 28, 265

[4] ORR (1936) *Food Health and Income* Macmillan & Co

[5] CRAWFORD and BROADLEY (1938) *The People s Food* Heinemann

[6] STETTNER (1931) *Zeit f Kinderheilk* 51 435 and 1932 52 1 Quoted by Leitch

foods and making use of all priorities to obtain calcium up to the assessed requirements except during adolescence[1]

There is obvious reason therefore, for estimating the need for calcium of people of all ages for it is clear that many people in all parts of the world are in danger of obtaining too little. The minimum amount for maintaining balance of calcium in the adult has been obtained in a similar way to that used for protein. It is not sufficient to take the lowest amount of calcium in the food which just balances the loss of calcium from the body in the excreta for both positive and negative balances may occur on quite a large or small intake. This is due to mobilization from the bones by extra parathyroid activity or to deposition of calcium in the bones under the influence of vitamin D

The figure obtained by Leitch[2] is 550 milligrammes per day. If as seems reasonable we allow a 50 per cent margin for safety we reach a figure of 825 milligrammes per day. There are certainly many people who do not attain that figure though the average figure in the 63 men investigated by Widdowson was 870. In the women it was 630. It may be that the figure of 825 milligrammes is too high. Sherman suggests 680. But whatever the truth may be we can be sure that our needs for calcium will be easily covered if we increase the consumption of milk in this country to the level the dietitian demands i.e. at least 1 pint per day. One pint of milk contains 680 milligrammes of calcium

Pregnancy in its last three months, entails an increase in calcium consumption on the part of the mother. Otherwise her bones will be depleted to make good the needs of the fœtus when its bones are ossifying. Maxwell gives evidence from his experience in China that earlier pregnancies so deplete the skeleton of the pelvis that in later pregnancies it is deformed and the infants have to be delivered by Cæsarean-section. It is possible that the funnel shaped pelves seen in this country in multipara of the poorer classes are due to such loss of calcium

The main work on the calcium needs of women in the last 2½ months of pregnancy we owe to the Toveruds[3] of Oslo. They investigated the calcium of women during that time in a small maternity hospital which preferred to have the mother in hospital throughout that period. Making assumptions based upon

[1] Todd (1934) *Journ Home Econ* 26 605 quoted by McCollum Orent Keiles and Day (1939) *The Newer Knowledge of Nutrition* states that osteoporosis is common in adolescence in the U S.A

[2] Leitch (1937) *Nut Abs and Rev* 6 533

[3] Kirsten and Guttorm Toverud (1931) *Acta Pædiatrica* 32 Supplement II

analyses of the bones of prematurely still born children they could, by analysis of the food and the calcium excretion of the mother in the excreta discover whether their women were in positive or negative calcium balance At first they could never obtain a positive calcium balance on the diet usually served in the hospital They then altered the diet, increasing the amounts of milk, cheese, and green vegetables, and adding cod liver oil in the winter months and still could not obtain a positive calcium balance till they brought pressure to bear upon the women to take the new diet Then when the calcium intake rose to the high figure of 1 6 grammes per day they were able to establish a positive balance Such a figure we must therefore take as a requisite for women in the last months of pregnancy Similar results have been obtained in the United States [1] One confirmatory piece of evidence is that X rays showed the bones of the skull and the long bones of the child when born to be better calcified when the mother had had a diet satisfactory in calcium than when she had not The figure of 1 6 grammes has been accepted by the League of Nations Technical Commission and by most who have investigated the subject [2]

Of the 120 pregnant women investigated in this country one only reached this optimal figure [3] She belonged to the well to do class and owed her high calcium intake (1 75) grammes mainly to the large quantity of milk taken (37½ oz or nearly 1 quart) 17 took over 1 0 gramme per day and in most cases this was due to a high milk intake In only one case did cheese partly account for the large amount taken If the estimate we have accepted be correct the majority of the women investigated must have been depleting their bones of calcium or would deplete it, according to the stage of pregnancy they were in, if they continued on this régime

Lactation also involves a strain upon the maternal organism Assuming a secretion of 1½ litres of milk per day with a calcium content of 0 32 gramme per litre, we get a loss per day of 480 milli grammes of calcium This plus the normal daily need will demand

[1] E g in Coons and Hunscher and also by Macy and associates (1930) *See J Biol Chem* 86 59, and (1931) 90, 675

[2] The observations of Graham and Oakley (1938) *Arch Dis Child* N S I 1 in cases of renal rickets showed that a positive calcium balance can be obtained with 1 gramme of calcium when large doses of vitamin D—3000 to 6000 I U were given These experiments suggest that it may be unnecessary to give so large an amount of calcium as 1 6 grammes if larger amounts of vitamin D are added to the diet

[3] McCance Widdowson and Verdon Roe (1938) *Journ Hygiene* 38, 596

an intake of at least 1160 milligrammes or a quantity found in about 1½ pints of milk Should the milk secreted contain still greater amounts of calcium, and figures are quoted by Leitch[1] up to 0 72 grammes per litre, the intake of calcium will have to be still further increased A quart of milk per day would not cover such an output

The *calcium needs of infants* can be calculated from a knowledge of the relation of weight of skeleton to the body weight and the calcium content of the skeleton From the records we have, we gather that a figure of 8 grammes of calcium per kilogramme body weight represents the calcium of the body at birth To maintain but not to increase this proportion the retentions for the first six months of life would be 104 218, 200, 192 176, and 135 milligrammes per day respectively at a moderately slow rate of growth The retentions observed on babies of the working class quoted by Leitch are actually below these figures so that if the assumptions made are correct the bones of the babies will be less ossified at six months than at birth Only if the yields of mother s milk are above 175 c c per kilo body weight of the baby and the milk contains over 0 3 per mille of calcium are the retentions of calcium likely to be enough to cover the baby s needs

With cow s milk a sufficient retention is more difficult to obtain because though the calcium content is high the curd of cow s milk is difficult to digest. Treatment of the milk with acid or with calcium chloride and feeding it to the baby along with cod liver oil overcomes the difficulty of digestion and absorption Iowa pediatricians[2] claim by these means to have obtained retentions in excess of those necessary to maintain the skeleton as well calcified as it is at birth

Similar calculations can be made for children over the age of one year We give the figures obtained as a guide to the calcium requirements of boys at different ages (See next page)

The figures are compiled from average weights for American children up to 5–6 and thence on from figures for preparatory and public school boys Until the age of 10 the amounts suggested do not reach the level given by Sherman as desirable Beyond that age they are much in excess The greatest increase in height occurs around the 16th year and if the skeleton is to be reasonably ossified it is at that time that the greatest need for a good calcium intake occurs It will be remembered that Friend the medical officer of Christ s Hospital states in his book[3] " that the incidence of broken bones increased remarkably in the rationing years

[1] LEITCH (1937) *Nut Abs and Rev* 6 553

[2] JEANS (1933) *Amer Journ Dis Child* 44 69 quoted by Leitch

[3] *The Schoolboy* (1935) Heffer & Sons

	mg per day		mg per day
0 5–1	785	9–10	1000
1–2	702	10–11	1267
2–3	734	11–12	1375
3–4	737	12–13	1341
4–5	650	13–14	1494
5–6	849	14–15	1381
6–7	845	15–16	1937
7–8	890	16–17	1841
8–9	841	17–18	1231

1917–1919 and did not fall to normal till 1923" At that time they were having difficulty at the school in supplying sufficient milk Leitch s figures have been criticized adversely as exaggerations of the truth, but all admit the truth of the trend of the calculations

We have painted a sufficiently gloomy picture of the attainment or the lack of attainment of the needs for calcium in the diet among several groups of the populace Figures given by Orr and Crawford and Broadley do not relieve the gloom Only the wealthiest classes obtain enough and estimates vary from 25 to 35 million out of the 45 million for those whose diet is inadequate And yet a sufficiency is so easy to obtain! We quote the cheapest conceivable diet 5 oz of cheese 2 lb 3½ oz national wheatmeal bread, and 4 oz cabbage This diet contains 1084 milligrammes of calcium assuming that none of the calcium of the bread is available The diet of a vegetarian who kept a complete record of the weight of all his food during the course of a week yielded no less than 2310 milligrammes of calcium [1] And in view of the foods which contain plenty of calcium—relatively cheap foods—there is little need that any but the poorest strata of society should go without their quota [2]

Distribution of Calcium in Foods *Meat* is of little value, the only exception being tripe which has been dressed with lime (127 milligrammes per 100 grammes) *Fish* frequently contain large amounts of calcium, especially those in which one can or is forced to eat the backbone *Milk* and its various products contain large amounts Contrary to current dietetic superstition *vegetables* and *fruits* contain almost useless amounts [3] *Brown bread* is extremely poor and probably a good percentage is unavail

[1] WIDDOWSON (1936) *Journ Hygiene* 36, 269

[2] But see note above p 105 on the difficulty of obtaining calcium upon war rations

[3] Figures from M R C Special Report 235 McCance and Widdowson

able, *white bread* has less but probably it is all available [1] (The problem of the milling of flour will be considered later) Should a person drink one quart of water with the hardness of London water (17 grains per gallon) he would obtain 243 milligrammes calcium no mean amount But if the water had been boiled previously as in the making of tea some of the calcium would have been precipitated Vegetables boiled in hard water actually increase their quantity of calcium because boiling the water precipitates the calcium and the vegetables form a convenient nucleus upon which it can be precipitated Soft water, like that of Liverpool is useless in supplying calcium

The practical politics of obtaining sufficient calcium is easy, it is to increase the intake of milk and cheese McCance and Widdowson in various dietary studies have shown a close correlation between total calcium and milk intakes

They further state [2] that wholemeal bread so depresses the calcium uptake by the body that wholemeal flour should be fortified with 200 milligrammes calcium to every 100 grammes flour and 85 per cent flour with 120 milligrammes The eating of 1 lb of unfortified wholemeal bread needs the consumption of an extra $\frac{6}{10}$ pint of milk to balance its adverse effect on absorption of calcium This emphasizes the need of extra milk, or cheese in maintaining the calcium balance especially when whole cereals are eaten as in many advanced diets There is evidence of decalcification of the bones following a consumption of bread made from a flour of 95–96 per cent extraction in South Africa [3] and of rickets produced by 100 per cent extraction from Eire [4]

CALCIUM CONTENTS OF FOODS IN MILLIGRAMMES PER 100 GRAMMES

CEREALS AND CEREAL PRODUCTS [5]

Bread	Brown	18
	National wheatmeal fortified with calcium	57
	Wholemeal	25
Flour	English 70 per cent unfortified	19
	Manitoba	13
Macaroni		26

[1] There is but little phytate in white flour

[2] McCANCE and WIDDOWSON (1942) *Journ Physiol* 101 44

[3] MEYER OOSTHUIZEN and SHAPIRO (1942) *Lancet* 2 639

[4] PRINGLE REYNOLDS and JESSOP (1943) *J Med Ass Eire* and CROASDAILE COLLIS PRINGLE and JESSOP *Ibid* June 67 69

[5] With the exception of the white flours and rice these amounts of calcium are probably unavailable

	Oatmeal		55
	Rice		4
	Breakfast foods		26–98
FISH	Dabs fried		130
	Haddock		114
	Smelts		686 [1]
	Sprats		707 [1]
	Whitebait ,		859
	Cockles, Mussels, Oysters, Prawns, Scallops, Winkles		All above 110
FRUIT	Fresh	All except blackberries and black currants from 4–4	
	Dried	Currants	95
		Dates	[illegible]
		Figs	284
		Prunes	38
		Raisins	61
		Sultanas	52
MEAT		Bacon raw	7–14
		Beef, various cuts	4–10 (Silverside boiled 23
		Ham raw	14
		Liver	8–9
		Mutton raw	13
		Pork roast leg	5
		Sweetbreads	14
		Tripe	127
		Veal raw	8

MILK AND MILK PRODUCTS

Butter	15
Cheese (Cheddar type)	810
Milk, whole fresh	120
skimmed fresh	124
condensed sweetened	290
unsweetened	294
powder whole	895
skimmed	1225

VEGETABLES

Beans runner	33	Chips	1
Beetroot	32	Kale	20
Brussels sprouts	27	Leeks	5
Cabbage	65	Lettuce	2
Carrots	48	Onions	3

[1] The backbone must be eaten to obtain this amount

Potatoes	8	Turnips	59
Radishes	44	Turnip tops boiled	98
Swedes	56	Watercress	222

Note —Spinach (595) and Rhubarb (103) have been omitted from the above tables because it is almost certain that their calcium is rendered unavailable by the oxalates present

Phosphorus

We have seen that phosphorus appears in many parts of the body both in its framework and structural units and as a catalytic and a buffering agent Its use in the latter capacity in the urine results in a loss to the body of approximately ¾ gramme of phosphorus per day That at least must be made up In fact there is a demand for phosphorus in foods at least as high as or higher than that for calcium In the adult if phosphorus be lacking in the diet the body can draw upon its apatite quarry of the bones for the lacking element in growing animals this is not possible and a low phosphorus intake limits growth There is an optimal relation between calcium and phosphorus in the diet which is about 1 1 or possibly 1 1 5 It is known that in rats a high calcium low phosphorus and a low calcium high phosphorus ratio both limit the rate of growth and in the absence of vitamin D conduce to rickets In milk the ratio of Ca P is as 1 27 1 Most text books accept Sherman s suggestions for a reasonable intake of calcium and phosphorus which lead to a ratio of Ca P of 1 1 91 but there is no evidence of what is the optimal ratio Let us assume at the present it is 1 1 that is to say that if the adult man needs 680 milligrammes per day the non pregnant woman needs 476 (i e 0 7 of the male need) the pregnant woman up to 1474 at the end of pregnancy and growing children from 785 to 1937

Now there are parts of the world where phosphorus is deficient e g South Africa, and there is evidence of phosphorus deficiency among farm animals in all parts of the world But the human diets investigated reach even the high estimates of phosphorus need by the League of Nations Technical Commission which are higher than those suggested here Consequently there need be little trouble concerning phosphorus intakes It is almost certainly true that if the *calcium in the diet is adequate the phosphorus will be adequate too* That is because milk cheese and the fish which we take for their calcium have a high phosphorus content as well

This raises the question In what form does the body obtain its phosphorus ? It is certainly mainly but not entirely in organic combination Half the phosphorus in milk is in combination with the protein caseinogen The vitellin of egg yolk also has phos

phorus as an integral part of its molecule Again in the nucleo-proteins it is in combination Possibly in meats the creatine phosphate the compound of riboflavin and phosphoric acid and the adenyl pyrophosphate are all hydrolysed during digestion so that the phosphates are free and uncombined Anyhow we know that the phosphoric acid is freed by digestion from the caseinogen and vitelline where it is in combination with the amino acid serine And we know that a young growing animal can obtain all the phosphorus it needs from inorganic phosphates Consequently we assume that phosphorus enters the blood stream as a phosphate

One organic compound of phosphorus is found in cereals pulses and nuts and to a less extent in vegetables calcium magnesium inositol hexaphosphate There is evidence that this is of little or no value in nutrition for man possesses no ferment such as plants and rats possess which hydrolyses the phytates This shows that we must not accept the phosphorus contents of those foods as all available nor indeed their calcium and magnesium contents We must subtract from the total the phytate phosphorus [1] (see below)

Turning to the actual intakes by middle class people we find that all the men investigated obtained enough available phosphorus [2], so do most of the non pregnant women though there was one out of the 63 consuming considerably less [3] Amongst the pregnant women [4] there were few up to the standard that we have set and all those who achieved it had plenty of money to spend on foods The rest were moderately poor, or had unemployed husbands

Distribution of Phosphorus in Foods Milk and milk products have large amounts and so have eggs Meat and fish have moderately high amounts Cereals and pulses have less available phosphorus and fruits and vegetables minimal amounts Below are given some tables in illustration of this

AMOUNTS OF PHOSPHORUS IN MILLIGRAMMES PER 100 GRAMMES FOOD

DAIRY FOODS	Cheese	hard	544
		soft	481
	Milk	fresh whole	94–101
		skimmed	98–105
		whole evaporated unsweetened	254

[1] McCance and Widdowson (1935) *Bioch Journ* 29 2694
[2] Widdowson (1936) *Journ Hygiene* 36 269
[3] Widdowson and McCance (1936) *ibid* 36 293
[4] McCance Widdowson and Verdon Roe (1938) *ibid* 38, 596

Dairy Foods	Milk whole condensed sweetened	238
	,, skimmed condensed sweetened	270
	Egg per egg	124
Meats	Beefsteak raw	276
	,, grilled	303
	Kidney sheep raw	234
	,, fried	433
	Mutton chop lean raw	195
	,, grilled excluding fat	239
	Veal fillet raw	258
	cutlet fried	283
Fish	Haddock fillets raw	216
	,, fried	247
	smoked steamed	248
	Herring fillets raw	272
	(flesh) fried	339
	Kipper baked	426
Fresh Fruits	Apples English eating	8 6
	Currants black	43
	Gooseberries ripe	19
	Raspberries	29
	Strawberries	23
	Tomatoes	21
Dried Fruits	Currants	40
	Dates	65
	Figs	92
	Prunes	83
	Raisins	33
	Sultanas	05

Cooked Vegetables All range from about 29–90

As we have said above, compounds of phytic acid are often present in cereals and vegetable products usually in the form of calcium magnesium inositol hexaphosphate Unless these foods contain phytase and in process of cooking this phytase gets a chance to work [1] (as to some extent it does in bread making) most of the phosphorus of the phytates is unavailable to the body This not only is a deprivation in itself but in addition as we have said in the previous section the phytates blanket calcium from any source Consequently the presence of phytate phosphorus in a food is a serious consideration Below is a table giving figures for phytate and non phytate phosphorus in foods based on McCance and Widdowson s figures for English foods [2]

[1] McCance and Widdowson (1944) *Nature* 153, 650
[2] McCance and Widdowson (1942) *Med Res Counc Report* 235

	Total Phosphorus mg /100 g	Phytate Phosphorus mg /100 g	Non phytate Phosphorus mg /100 g
CEREALS			
Bread White 70–72 per cent extraction	73	11	62
National Wheatmeal, 85 per cent extraction	142	43	99
Wholemeal 92 per cent extraction	179	100	79
Flour White 70–72 per cent extraction	102	31	71
National Wheatmeal 85 per cent extraction	206	113	193
Wholemeal 92 per cent extraction	287	201	86
Oatmeal	380	266	114
Tapioca	30	0	30
VEGETABLES			
Beans butter raw	318	267	51
haricot raw	309	225	84
Lentils	242	123	119
Peas dried	303	242	61
split	268	152	116
PROPRIETARY CEREALS			
All Bran	815	620	195
Cornflakes	*58*	*15*	43
Ryvita	295	159	136
Shredded Wheat	287	230	57
Vita weat	372	220	152
NUTS			
Almonds	442	362	80
Brazils	592	510	82
Chestnuts	*74*	*13*	*61*
Cobnuts	229	185	44
Peanuts	365	208	157
Walnuts	510	214	296

It is extraordinary how little support the enthusiasts for whole and laxative cereals and for vegetarian substitutes for sources of animal protein get from these tables though they were not compiled with any other motive than displaying facts, concerning available calcium and phosphorous in the diet

Iron

That a regular absorption of iron from the food is essential is a platitude, but the problem of how much per day and in what form is still extremely undecided Two important considerations have recently unsettled any decision The first is that we are uncertain whether the iron in food must be in an ionized form if it is to be absorbed For years it has been known that the iron of hæmoglobin is ill digested and ill absorbed Moreover, foods which on the analysis of their ash have abundant iron do not yield this up to the body any better than foods which have less Thus spinach which has 4 milligrammes per 100 grammes is no better in the treatment of an artificially produced anæmia than tomatoes which have 0 43 milligrammes[1] So that before we dogmatize as to which food is 'good for iron and which not we must learn the actual availability in biological experiment

Secondly the old assumption that iron can be excreted from the blood into the large intestine has been vigorously questioned and to our minds rightly so[2] Any iron the body absorbs it retains tenaciously It does not necessarily use it to manufacture hæmoglobin In fact the retentions may be as much as twice the iron already in the blood stream in the red corpuscles and though the hæmoglobin may increase in amount it is not increased in proportion to the iron absorbed[3] The iron is presumably stored in the reticulo-endothelium of liver and spleen where it can lie *perdu* until it is needed If this be true it upsets the arguments from most iron balance experiments It is conceivable that a person should remain in apparent iron equilibrium on a diet containing practically no iron The small losses from shed epithelial cells and in secretions could be made good from the stored iron To estimate the normal need of iron in the diet from the results of a number of iron balance experiments would be wrong unless we know that the subjects of the experiment have no iron secreted about their persons

The history of our iron stores is probably as follows We are born with from 266 to 937 milligrammes of iron[4] and on an average

[1] The figures here given are for English vegetables from McCance and Widdowson (1942) *Med Res Council Report* no 235 but the experiments quoted were by Tisdall, Drake Summerfeldt and Jackson (1937) *Journ Pæd* 2, 374 Their vegetables were nearer together in their content of iron

[2] McCance and Widdowson (1937) *Lancet* 2 680

[3] Widdowson and McCance (1937) *Bioch Journ* 31 2029

[4] Coons quoted by McCance Widdowson and Verdon Roe (1938) *Journ Hygiene* 38 596

400 milligrammes This is mainly present as hæmoglobin in red blood corpuscles and there is excess of it The hæmog level of new born baby s blood is 145 per cent (Normal is t as 100, which corresponds to 13 8 grammes hæmoglobin or milligrammes iron per 100 c c blood) The red blood corpu in excess of needs at birth are promptly disrupted and the hæ globin level falls The iron from the disrupted blood corpu is retained and is doubtless used little by little to form more hæ globin as we grow For the first six months of life we o very little iron in our food Human milk contains but a amount and cow s milk less The hæmoglobin may fall to 7(cent in breast fed babies and to as low as 40 per cent in artific fed babies [1] This fall may be prevented in the artificially babies by combining iron with the milk fed When this is the morbidity rate is greatly lessened so the fall must be consic pathological There is evidence that if the mother is ana though the baby may start with a high hæmoglobin figure stores of iron are low and the ultimate hæmoglobin level is l than normal From the time when the baby gets on to solid f containing iron the hæmoglobin rises and should become nor although it is usual in poorer neighbourhoods to discover a level till the child has reached the age of 3 or 4 years The hæ globin level is determined by the amount of available iron in food After puberty there is a drain upon the iron of the l in girls at the monthly periods which may be reckoned at al 40 milligrammes of iron per period though lower figures recorded If insufficient iron is taken in the food, the hæ globin level sinks As a result it is common to find figures women at the 70–80 level and a level of 90 is considered nor This figure can be raised by iron medication (100 milligram per day) by as much as 10 per cent [2] The usual level of 10C the male is usually not so raised but there are exceptions [3] example, one man with the high figure of 116 had this raised 10 per cent on taking 1000 milligrammes of iron spread over 46 d A similar increase of as much as 20 per cent occurred in on us (V H M) following an intake of 65 milligrammes per day for months The figures for the hæmoglobin of American males is c between 110 and 120 These results suggest that possibly both and women do not get enough iron in their diet in this coun

The pregnant woman has a still further drain on her iron,

[1] MACKAY GOODFELLOW and BRADFORD HILL (1931) *Med Council Report* No 157

[2] WIDDOWSON and McC *Journ Hygiene* 36 13

and McC *Bioch Journ* 31 2029

though the amount of iron representing the suppressed periods is saved, she hands over some 100 milligrammes to the fœtus, and another 500 milligrammes to the placenta and may lose considerable iron in addition at parturition Pregnancy and childbirth make for anæmia, as is shown by investigations upon women in our poorer districts Men on a diet similar to that which results in anæmia in women can achieve a normal hæmoglobin level *unless there be loss of blood owing to hæmorrhage*

It all comes to this that our source of iron is in food and that the intake should be adjusted so that we have an excess over what is necessary to keep the hæmoglobin level at its optimal figure What that is we do not yet know but it may be taken, in want of further evidence at 100–110 As the foods which contain iron are few and there is rarely much in them and not all is available it might be well to consider taking medicinal iron in emergencies and, at any rate to ensure a good store of iron in pregnancy by high iron feeding

Estimates for desirable iron intake are *15 milligrammes total* iron (Sherman) for the adult male and female and 20 milligrammes per day for the pregnant female (McCance, Widdowson and Verdon Roe) The National Research Council of the U S A gives the more modest figures of 12 and 15 milligrammes respectively Children this Council estimates, need 6 rising to 12 with 15 to cover the years of adolescence The average intake for 63 men investigated by Widdowson and McCance was 16 8 and for the women it was 11 8 milligrammes of which 10 8 and 7 9 respectively were ' available For pregnant women the figures run from 14 8 milligrammes (10 3 ' available) in the more well to do to 8 6 (6 4 available) in the poorest class Clearly if the estimates given above are well founded there is a grave deficit of intake in the women pregnant and non pregnant

Distribution of Iron in Foods The following table gives the iron content in milligrammes per 100 grammes of food [1]

FRUITS FRESH	Cranberries	1 11
	Currants black	1 27
	red	1 22
	Loganberries	1 37
	Raspberries	1 21
FRUITS DRIED	Apricots	4 09
	Currants	1 82
	Dates	1 38 [2]
	Figs	4 17

[1] The figures are mainly from McCANCE and WIDDOWSON (1942) *Med Res Council Rep* No 235

[2] Weighed with stones

FRUITS DRIED	Peaches	6 75
	Prunes	2 41 [1]
	Raisins	1 55
	Sultanas	1 82
NUTS [2]	Almonds	4 23
	Barcelonas	2 97
	Brazils	2 82
	Cob	1 06
	Coconut	2 08
	Peanut	2 04
	Walnuts	2 35
RAW VEGETABLES	Endive	2 77
	Mustard and Cress	4 54
	Peas green	1 88
	Radishes	1 88
	Spring Onions	1 24
	Watercress	1 62
COOKED VEGETABLES	Baked Beans	2 05
	Broccoli tops	1 52
	Butter Beans [3]	1 67
	Haricot Beans [3]	2 50
	Leeks	2 00
	Lentils [3]	2 20
	Peas dried [3]	1 44
	,, green	1 22
	,, split [3]	1 74
	,, tinned	1 87
	Salsify	1 23
	Spring greens	1 33
	Turnip tops	3 08
CEREALS [3]	Barley	3 6
	Bread brown	2 7
	white	1 0
	Cornflour	1 5
	Oatmeal	3 8
	Rice brown	2 0
	white	1 5
SUNDRIES	Fried mushrooms	1 25
	chips	1 35
	Eggs per egg	1 58

[1] Weighed with stones

[2] Kernels only Probably the phytates of nuts render this iron unavailable and iron from other foods as well WIDDOWSON and MCCANCE (1942) *Lancet* 1, 588

[3] It is doubtful if the iron is available in pulses the whole cereals and the proprietary cereals WIDDOWSON and MCCANCE (1942) *Lancet* 1 588

SUNDRIES	Kidney, ox, stewed	7.1
	,, sheep, fried	7.9
	Liver	5.2–8.9

Shell fish have a high iron content, cockles, mussels, oysters and winkles having from 15 to 26 milligrammes. It is not known if this iron is available.

The iron contents of some of the proprietary cereal foods are here given.[1]

	mg per 100 grammes		mg per 100 grammes
Force	3.09	Ryvita	3.73
Grape Nuts	5.61	Shredded Wheat	4.48
Kellogg's All Bran	10.8	Vitaweat	3.10
Post Toasties	1.07		

A few figures for meat and fish are included although much of the iron may be unavailable. (Hæmoglobin is indigestible.)

Bacon, raw	0.92	Herring, fried	1.87
,, fried	2.79	Kidney, fried	7.93
Beefsteak, raw	4.30	Mutton, roast	4.35
topside, roast	8.89	Plaice, steamed	0.60
Bloater, fried	1.62	Pork, roast	2.22
Chicken, roast	2.61	Rabbit, stewed	1.90
Haddock, smoked, steamed	0.99	Salmon, steamed	0.81
Ham, lean, boiled	2.61	Sole, fried	1.42

It is unfortunate that we cannot wholly rely on these tables as a guide to obtaining the requisite amount of iron. It has been shown that the iron enters the blood-stream probably in the form of ferrous salts and not in organic combination as was once thought. One such organic combination is the phytate. Iron phytate is particularly insoluble. Consequently the phytates of whole cereals, bread and biscuits made from them, blanket the iron in these cereals and possibly also some of the iron in the rest of the food. Only animals which have a phytase in their gut can avail themselves of the iron of the whole cereals, nuts and pulses. Now man has no phytase while the rat has. It was therefore unfortunate that the rat was the animal in which the blood regenerating power of whole cereals was demonstrated. McCance and Widdowson have shown that in man the *use of wholemeal bread depresses the amount of iron absorbed from the food*,[2] probably as the result of the phytates it contains. People in the past who ate white bread may have been anæmic, but probably would have been still more anæmic if they had eaten wholemeal bread.

We are, however, fairly certain of the value of liver, kidney,

[1] *ibid*

[2] McCANCE and WIDDOWSON, *op. cit.*

eggs, the greens (except spinach), dried fruits and treacle Chappell[1] working with McCance and Widdowson has shown that using ordinary, and not stainless steel knives in the preparation of vegetables and chipped enamelled saucepans with the iron basis exposed, notably increases the iron content of the cooked food Presumably all this iron is available So this observation suggests that we put a premium upon rusty iron knives and saucepans in our culinary work rather than on stainless steel and aluminium modern kitchen equipment If patients need more iron it is best to give it as some iron salt (e g ferrous sulphate) to restore them rapidly to normal

Iodine

This element is necessary but in very small amounts It has been estimated that as little as 14γ (fourteen thousandths of a milligramme) per day is sufficient, other estimates are 45γ for an adult and 150γ for a child and one by Eggenberger of the Canton of Appenzell in Switzerland, where the relation of iodine to goitre has been intensively studied 1–2γ per kilogramme body weight, i e 70 to 140γ for the average man and 56–112γ for the average woman

Though such small amounts are necessary there are many parts of the world where too little is obtained These regions are in England the Pennines, particularly in North Derbyshire, the Cotswolds the Mendips, in Europe the Pyrenees the Alps in Asia the Caucasus, the Himalayas and the central Asian plateau, in America the Rockies and around the Great Lakes Deficiency results in an overgrowth of the thyroid gland called 'goitre — Derbyshire neck in England This goitre can usually be relieved by giving salts of iodine or food containing iodine Around the Great Lakes in North America 35 per cent of the school children once had enlarged thyroids This number has now been reduced to 1 per cent by the addition of potassium iodide in small amounts to their intake The same is true of Switzerland where the incidence of simple goitre has been enormously reduced (it was endemic) by the use of iodized salt In the Vorarlberg Tyrol province in Austria 59 per cent of the boys and 63 per cent of the girls had thyroid trouble This has been reduced to one tenth and much of the reduction is put to the credit of iodized salt[1] The reason given for the occurrence of goitre is absence of iodine from the drinking water and from the soil, though there is some evidence that presence of lime in the drinking water antagonizes the effect of the iodine in it In New Zealand there is a distinct parallelism between the

[1] *Lancet* (1939) 1, 1061

incidence of goitre and the deficiency of iodine in the soil, but in this country the parallelism is not complete [1]

Be that as it may it is certain that the giving of iodine either as foods containing iodine or as iodized salt (1 part of iodine in 200 000 sodium chloride) will prevent the occurrence of simple goitre

The foods which contain iodine are the sea fish and the edible seaweeds As the thyroid is more active at puberty, during pregnancy and the menopause these are times when especial attention should be given to the provision of fish in the diet The content of fish is as follows

	γ per 100 grammes		γ per 100 grammes
Cod	120	Oysters	120
Herring	200	Salmon	140
Mussels	190		

Watercress also contains fair amounts and so does the onion if grown on soils with a reasonable amount of iodine, but the amounts compared with that of sea fish and edible seaweeds are very small—in the region of a few γ only per 100 grammes The immunity of the Japanese to goitre is thought to be due to their consumption of edible seaweed There is no danger of obtaining an excess of iodine as the result of eating iodine rich foods but there is of course a danger that too much iodine may be taken in the form of iodized chocolates etc, and it may cause toxic changes to occur in patients with long standing adenomatous goitres So far no ill effects have been noticed in Switzerland from the addition of 5 milligrammes of iodine to 1 kilogramme of salt (or 1 in 200 000) as a result of many years experience Marine is of opinion that the addition of 10 milligrammes of iodine to 1 kilogramme of salt (1 in 100 000) is the concentration to be preferred because it takes care of a wider range of iodine deficiences with no appreciably greater risk Marine has seen twelve patients who developed toxic changes after using iodized salt but was able to show that other preparations of iodine had been given at the same time [2]

Iodine plays a part in two other diseases of the thyroid In myxœdema where the thyroid is atrophied the iodine content of the blood is very low while in toxic goitre it is considerably raised The latter condition is greatly benefited by the giving of iodine but iodized salt does not contain sufficient and it is necessary to give 3 to 4½ grains of iodine a day for 10–14 days before operation

[1] ORR (1931) *Med Res Council Rep* No 154

[2] MARINE D (193.) Glandular Physiology and Therapy *J Amer Med Assoc* 356

Sodium

The study of sodium in the diet has in recent times become important, as the result partly of the effects of the loss of sodium from the body in intense perspiration and partly of the discovery that the cortex of the suprarenal body governs the excretion of sodium salts by the kidney Some of the symptoms of Addison's disease are almost certainly due to the direct loss of sodium and chlorine from the blood [1] (The apparent *increase in potassium is* due to the decrease of the volume of the blood in this disease) *As much as 28 per cent of the sodium and 33 per cent of the* chlorine may be lost from the blood in Addison s disease It is almost certain that the loss of the sodium is the operative factor, for other sodium salts can take the place of sodium chloride in alleviating the symptoms

Loss of sodium as the result of intense sweating, may produce symptoms very similar to those seen in Addison's disease viz muscular weakness, dyspnœa after slight exercise languor, mental confusion drowsiness Stoker s and miner s cramp is now recognized as being due to a loss of sodium from the body which is not replaced unless salted water is taken instead of water or similar beverages *Sweating in hot climates may give rise to unrecognized* ill health, and this may be serious and even fatal A man may *lose 3000–4000 milligrammes of sodium in a day by sweating,* as was shown in a series of experiments by McCance and his colleagues with resulting symptoms closely paralleling those of Addison' disease [2] Three hours exercise in the sun may result in a loss sodium chloride in the perspiration equal to a whole day s sal ration [3] The symptoms of Addison s disease may be aggravate by cutting down the sodium intake and increasing the potassiun intake by an exclusively vegetarian diet Heat Exhaustion,' Type I, with its main symptoms vomiting and cramp, as the resul of exposure to desert climate is due to a loss of sodium and car be obviated or cured by increased salt consumption In extreme cases intravenous injection of normal physiological saline is advisable [4]

In normal dietetics there is never any likelihood of a depletion of sodium, for most of us take more than enough in food But

[1] Loeb quoted by GRAHAM (1937) *Postgrad Med Journ* 88 See also HINDS HOWELL (1934), *Lancet* 1, 1116

[2] *Lancet* (1936) 1 823

[3] DILL HALL and EDWARDS (1938) *Amer Journ Physiol*, 123 412

[4] LADELL WATERLOO and FAULKNER HUDSON (1944) *Lancet* 2, 491 527

if work or exercise is undertaken in hot surroundings there is a danger of such a depletion Some persons lose sodium in their perspiration much more readily than others and these if they undertake arduous work or exercise in hot weather or hot surroundings should make up their deficit by drinking slightly salted water A level teaspoonful of common salt to a pint of water, which is approximately 'normal saline,' forms a convenient drink for replenishing the body's store of sodium in these conditions

In medicine when there is a depletion of the stores of sodium by excessive vomiting or diarrhoea or of course in Addison's disease, saline should be given instead of water for the same reason In all cases when a "salt-poor" or "salt-free" diet is indicated the effects of depletion of the sodium in the extracellular fluids of the body must be borne in mind Anchovies bacon caviare, cheese haddock (smoked), ham kippers green olives salt fish and salt pork and sausages are acceptable as a means of supplying sodium in sodium depletion if saline is disliked

Potassium

Whereas sodium is the element found in the greater amount in the extracellular fluids of the body potassium is found in the cells For example 320 milligrammes of potassium are found in 100 grammes of muscle, whereas in the plasma of blood there are only 20 milligrammes [1] Consequently in the building of tissues potassium is needed in the diet In the course of the day as much as 3 grammes may be lost in the urine and thus must be replenished [2] There is, however, no evidence that anyone suffers a deficit of potassium in the diet, for so many foods are relatively rich in that element All plant foods even white bread contain much potassium all animal tissues are likewise good sources and the only foods with really small amounts are butter cornflour margarine suet tapioca and (surprisingly) tripe

It is therefore difficult to avoid obtaining enough potassium and still more difficult to devise a diet low in potassium as is advisable in Addison's disease Such a diet has to be based on white bread butter rice, and vegetables cut in pieces and boiled in a large volume of water but with care a palatable diet can be prepared [3]

[1] Best and Taylor (1937) *The Physiological Basis of Medical Practice* Baillière Tindall & Cox

[2] *ibid* This figure naturally falls during a fast but even on the 31st day of a fast the amount excreted is 606 milligrammes which proves that potassium enters into the metabolic processes of the body and that the excreted potassium in an ordinary diet is not merely exogenous

[3] Abrahams and Widdowson (1937) *Modern Dietary Treatment* Baillière Tindall & Cox

POTASSIUM CONTENTS OF FOODS

		Milligrammes per 100 grammes
FISH	Cod steamed	360
	Haddock steamed	323
	Plaice steamed	278
	Turbot steamed	255
FISH SMOKED AND PRESERVED	Bloaters	446
	Kippers baked	520
	Sardines	433
MEAT FRESH	Beefsteak grilled	368
	Mutton chops grilled	266
	Pork roast	308
	Rabbit stewed	210
MEAT PRESERVED	Bacon fried	517
	Ham boiled	454
	Beef salt	288
POULTRY	Duck roast	319
	Chicken roast	381
OFFAL	Liver calf fried	407
	Kidney sheep fried	304
	Tripe stewed	9
EGGS		134
FRUIT	Apples	116–23
	Bananas	348
	Grapes	250
	Grape fruit	234
	Orange juice	179
	Pears	129
	Plums	188
	Strawberries	161
	Tomatoes	288
FRUIT DRIED	Currants	708
	Figs	1015
	Prunes	864
NUTS	Almonds	856
	Brazils	760
	Walnuts	687
VEGETABLES BOILED	Cabbage	144
	Carrots	87
	Peas	293
	Parsnips	293
	Potatoes	325

Sulphur

Sulphur is the one element apart from carbon hydrogen nitrogen, and oxygen which is absorbed into the body almost entirely in the

form of an organic compound It is present in most proteins as the amino-acids methionine or cystine or both and is absorbed into the system in that form Possibly small amounts of sulphates in solution are absorbed in the foods eaten, but their importance in diet is minimal The amino acids mentioned are important not only in the construction of human proteins but also of glutathione, a cell catalyst Further the sulphur from them must be used in the synthesis of vitamin B_1 There is sulphur in insulin and in taurocholic acid one of the acids in bile salts which play an important part in the digestion of fats

Most of the sulphur in the food when metabolized is converted into a sulphate and excreted in the urine as such though some is detached as cysteine, or converted into glutathione thiocyanates etc which perform essential functions in the body Some sulphur containing amino-acids in the form of protein are essential in the diet and it is probable that methionine is the main one In a mixed diet there is little likelihood of a deficiency, for egg albumin lactalbumin myosin ovovitellin and gliadin proteins from egg milk, meat and cereals all contain over 1 per cent of sulphur It is suggestive that egg albumin and lactalbumin, proteins pre eminently connected with growth contain the largest amounts of sulphur, i e 1 62 and 1 73 per cent respectively [1]

Magnesium

That magnesium is essential to the body is obvious from work on animals such as rats and dogs Deficient magnesium in the diet leads to marked vaso-dilatation, nervous irritability, con vulsions and death (McCollum and associates) [2] Human deficiency is unlikely because magnesium is widely distributed in all foods in small but significant amounts Omitting the whole cereals nuts and pulses where the magnesium is present as phytates and therefore not available, we find double figures in milligrammes of magnesium per 100 grammes in many foods About 200 milli grammes are excreted per day and it is unlikely that there will ever be a deficiency in the human diet Any excess of this metal in the form of salts in the diet is absorbed with great difficulty, and excess in the blood is excreted rapidly in the urine [3]

[1] Osborne quoted by Sherman (1937) *Chemistry of Food and Nutrition* Macmillan Co

[2] McCollum Orent Keiles and Day (1939) *The Newer Know ledge of Nutrition* 161

[3] McCance and Widdowson (1939) *Biochem Journ* 33, 523

Chlorine

Chlorine is an element which is taken into the body almost entirely as a soluble chloride and mainly as the chloride of sodium or common salt The majority of people add salt to their food as a condiment in amounts which altogether outweigh that naturally in the food That this is a matter of taste and not necessity is shown by the fact that the Eskimo does not do so, and it is even possible that the herbivora, about whose desire for salt licks" so much play has been made, take it for the same reason That salt is more essential in hot climates than cold has already been mentioned, but it must be realized that this is more for the sodium that it contains than for the chlorine

The body is tenacious of its chlorides and in chloride starvation it reduces the excretion from the high level of 7 or 8 grammes per day to as low as 0 2 In pneumonia the excretion of chlorides may be suppressed till the crisis is past

Chloride intake is essential for the production of the hydrochloric acid in the gastric juice, for maintenance of osmotic pressure in the tissue fluids and in enabling the blood to carry carbon dioxide If it were not for the chloride shift from plasma to red blood corpuscle as the blood becomes venous the blood could not carry its load of carbon dioxide from the active tissues to the lungs The presence of normal amounts of chloride in the plasma of the blood is thought to be necessary in keeping the calcium of the plasma ionized, thus preventing tetany

Chlorides (estimated as chlorine) in foods vary from the trace found in apricots, cherries, plums, and similar fruit to such a high percentage as 4 5 in fried bacon, most of which is added in pickling As the majority of people add salt to nearly every cooked and uncooked food with the exception of fruit (though Americans are known to take salt with fresh cantaloupe melon) there is no likelihood of any deficit in the diet There are occasions however in dietetics when a salt poor or a salt free diet is indicated in which such foods as bacon, baked beans corned beef, salt beef bloater, salt butter and margarine smoked haddock kipper meat extracts, olives, tinned salmon, sardines, sausage and shellfish are forbidden[1]

Trace Elements

In the table given on p 100 some elements are stated as being present in the body as traces and others as mere traces Taking them in alphabetical order aluminium arsenic, boron cobalt,

[1] Abrahams and Widdowson (1937) *Modern Dietary Treatment* Baillière Tindall & Cox

Nickel and Silicon These are invariably present in human tissues but there is no evidence that they are essential

Zinc As already mentioned this element is essential in the production of insulin and of carbonic anhydrase,[1] but zinc in small amounts is so widely distributed in food materials that it is doubtful if the human race ever goes short of it

Acid-Base Equilibrium

When the metallic elements present in food are oxidized in the body they give rise to bases and when the sulphur and phosphorus of the foods are oxidized they give rise to fixed acids viz sulphuric and phosphoric acids Both the bases and the acids are excreted in the urine and the reaction of the urine depends on the pre dominance of one or the other

In fasting the body is consuming its fats and proteins The main acid end product of fat metabolism (carbon dioxide) is elimin ated via the lungs and so does not affect the reaction of the urine The fixed end products of protein metabolism are acid Conse quently the urine secreted during the night or during a fast is acid because protein is being metabolized then Similarly the urine is acid when a high protein diet is eaten for its effect outweighs the alkali producing effect of fruits and vegetables[2] The urine will be alkaline on a diet containing much fruit and vegetables

Given the analysis of a food its influence on the urine can be with few exceptions calculated and the following table has been constructed on those lines[3]

(Ash from 100 gm is equivalent to c.c tenth normal alkali or acid.)

Bacon	average raw	75 acid	Peanuts	116 acid
,	back, fried	129	Peas fresh boiled	14
Bread	white	15	Peas tinned	29
	wholemeal	59	Pork leg roast	286
heese	Cheddar	54	Rice	76
		[illegible]	Sirloin beef roast lean	235
		162	Steak sirloin, raw	185
	white	74	Steak fried	173
	fresh steamed	177	stewed	289
		132	Walnuts	[illegible]

[illegible] (1940) *Bioch Journ* 34 1163 It is found also in
DAVIDSON (1942) *Bioch Journ* 36 252
and DU BOIS (1930) *Journ Biol Chem* 87 651
of the urine during the meat diet was increased to
of the acidity on mixed diets
WIDDOWSON (1940) *Med Res Council Report*

hæmoglobin though it is not included in the hæmoglobin molecule Copper deficiency in the soil interferes with blossoming and setting seed in plants It is associated with disease of cattle in Schleswig Holstein, the 'falling disease' of West Australia with 'piglet anæmia" throughout the world and with the "sway back' disease of lambs in limestone (and chalk ?) districts of this country From this evidence we should expect copper to be essential in human diet, and it has been guessed that we need 2 milligrammes per day[1] Excess of copper is poisonous but there is a big gap between the amount which will stave off trouble in animals and the toxic dose No evidence has been presented that human beings suffer from a deficit of copper but trouble may be expected in those parts of the world where farm animals show a deficit

Fluorine, once considered dispensable, has sprung into prominence because of its influence on the teeth[2] For example, the excellent teeth of the inhabitants of Tristan da Cunha which have been held in the past to support most systems of dietary, are now claimed to be due to the small but definite, amount of fluorides in the drinking water of that island When present in more than 1 part per million in the drinking water, fluorine leads to mottling of the enamel of the teeth (e g in Maldon Essex, where there are 5 p m m in the well water) Excess of fluorine interferes with bone metabolism in cattle, producing exostoses on long bones and mandibles a condition seen in those fed for example, on herbage to leeward of the prevailing wind near a group of brick factories

It is now guessed that the optimal concentration in drinking water is between 0 3 and 0 5 parts per million and experiments on a large scale are being made in the United States on the influence of fluorine on caries of the teeth It is hoped by controlled addition of fluorine to the drinking water of a town to stop that particular trouble of civilization

Manganese This metal occurs in the body in more than traces It is essential in the nutrition of birds, but is of less importance with mammals The few milligrammes thought to be important in human nutrition are provided by the otherwise adequate diet Manganese in relative large amounts is toxic

Molybdenum causes disease in farm animals in parts of central Somerset and elsewhere which can be prevented by ingestion of copper There is as yet no evidence of an effect on human beings[3]

[1] LAVERTON and BINKLEY (1944) *Journ of Nutr* **27**, 43
[2] See *Lancet* (1941) 1 23 375 701 and (1944) 2, 510
[3] FERGUSSON (1944) *Proc Soc Nutr* **1**, 215

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Given the analysis of a food its influence on the urine can be, with few exceptions calculated and the following table has been constructed on those lines[3]

(ASH from 100 gm is equivalent to c c tenth normal alkali or acid)

Bacon average raw	75 acid	Peanuts	110 acid
back fried	129	Peas fresh boiled	14
Bread white	16	Peas tinned	29 ,,
,, wholemeal	69	Pork leg roast	286
Cheese Cheddar	[illegible]	Rice	76
Cobnuts	39	Sirloin beef roast lean	235
Eggs	162	Steak sirloin raw	185
Flour white	74	Steak, fried	173 ,,
Haddock fresh steamed	177	,, stewed	289 ,,
Oatmeal	132	Walnuts	[illegible]

[1] KEILIN (1940) *Bioch Journ* 34 1163 It is found also in uricase DAVIDSON (1942) *Bioch Journ* 36, 252

[2] McCLELLAN and DU BOIS (1930) *Journ Biol Chem* 87, 651 The total acidity of the urine during the meat diet was increased to 2 to 3 times that of the acidity on mixed diets

[3] McCANCE and WIDDOWSON (1940) *Med Res Council Report* 235 H M S O

Almonds	183 alkali		Currants black	88 alkali	
Apples	28		Lemon juice	[illegible]	,
Bananas	79	,,	Lettuce	38	
Brazil nuts	45		Whole milk	27	
Brussels sprouts	8		Skimmed milk	23	
Butter beans dried	355	,	Onions raw	5	
Cabbage spring boiled	14	,	Oranges	61	,
Carrots raw	90		Potatoes raw	103	
Cauliflower, boiled	17	'	boiled	53	,
Celery raw	84	,	Prunes dried	203	
Chocolate plain	79	,	Rhubarb	130	,
Cocoa	7	,	Tomatoes	56	
			Turnips raw	65	,

Unfortunately the foods which have a preponderance of basic ions in their ash have been called basic foods and those which have acid ions, acid foods and this has given an opportunity to various food cranks to evolve ingeniously wrong headed systems of diet The table shows how misleading this is Lemon juice orange juice and tomatoes are called basic despite their acid taste, whereas meat and bread which are almost neutral to litmus are "acid" foods Taste and reaction to litmus are not a safe guide

In the case of such a substance as lemon juice this needs a little explanation It tastes acid because of the presence of an acid salt possibly dihydrogen potassium citrate The citrate part of the molecule and the hydrogen are oxidized in the body to carbon dioxide and water The carbon dioxide is eliminated from the body via the lungs leaving the potassium oxide, a highly basic substance to be eliminated via the kidneys and to increase the alkalinity of the urine

The question has arisen whether the "basic" and the "acid" foods should not be balanced in the diet so that the kidneys should not be given the trouble of secreting an acid urine It is often assumed with but the smallest excuse that the secretion of an acid urine is inimical to the kidney It can be said that in the normal person it does not matter one whit whether there is a balance between the two sorts of food or not According to Sherman, one of the foremost explorers of this region of dietetics the question must be regarded as still an open one in healthy persons In pathological conditions the balance is often of importance[1] If the kidney has difficulty in secreting sufficient acid to keep the alkali reserve within the normal limit of 55 to 70 volumes of CO_2 (25–31 5 mille molecules) per 100 volumes of blood the amount of

[1] GRAHAM G and OAKLEY, W G (1938) *Arch Dis Child*, N S 1 1

basic foods in the diet should either be increased or some alkaline salt, e g sodium bicarbonate, should be given as a medicine Similarly, if the kidney is unable to keep the alkali reserve down to the normal limits, the acid foods should be increased or acid salts given by the mouth In both cases the alkali reserve must be estimated at intervals to make certain that an adequate dose of alkali or acid has been given

It is also claimed that cystine stones in the pelvis of the kidney can be dissolved by giving foods with an alkaline ash,[1] but phosphatic stones cannot be dissolved by the use of foods with an acid ash

While on this subject of the acidity of foods it would be well to ask whether any of the acids which occur in fruits and vegetables appear unoxidized in the urine The answer is complicated by the fact that two of them oxalic and citric acids are almost certainly formed in intermediate processes of metabolism There is a normal excretion of 200–1200 milligrammes per day of citric acid 100–1500 of hippuric acid and 10–50 of oxalic acid[2] The acids of fruits are malic (apples plums quinces tomatoes etc) citric (citrous fruits pineapple tomato and most summer fruits) benzoic (cranberry and bilberry), tartaric (grape) oxalic (strawberries unripe tomatoes rhubarb, spinach and sorrel) The body seems to oxidize malic and citric acid nearly completely, tartaric is hardly absorbed at all oxalic may be absorbed and oxidized or excreted in the urine benzoic acid is excreted as hippuric acid Consequently the foods which concern us as regards acid base equilibrium are the foods which contain oxalic and benzoic acids

It is often alleged that when rhubarb and spinach are eaten oxalates are excreted in the urine (oxaluria) It is even further stated that eating the leaves of rhubarb as "greens" during the first World War caused fatal cases of poisoning There is certainly oxalic acid in the leaves[3] (0 30–1 11 per cent) and in the stalk from 0 44 to 0 99 and it is possible that if the oxalic acid is present as calcium oxalate boiling with soda to preserve the colour might transform some of the insoluble and safe oxalate into sodium oxalate which is poisonous Leafy vegetables from the spinach family (polygonaceæ) contain oxalic acid mainly as calcium oxalate The figures for spinach vary from 0 29[3] to 0 93[4] beet leaves

[1] Higgins (1940) quoted in *Lancet* 1, 82

[2] Sherman (1937) *Chemistry of Food and Nutrition* Macmillan & Co

[3] Most of the figures quoted are from Winton (1935) *Structure and Composition of Foods* vol 2 John Wiley & Sons

[4] Yeh and Adolph (1938) *Chin Journ Physiol* 13 209

0 62–0 75, and sorrel, which belongs to the related buckwheat family 0 27 per cent Other figures[1] are cabbage, 0 005–0 009, leeks, 0 017, lettuce, 0 002, rutabaga, 0 014, strawberries and tomato, 0 026 per cent[2]

The amounts of benzoic acid, both free and combined as a glucoside, in the cranberry and presumably in the whortleberry vary from 0 021 to 0 061 per cent This will be excreted as hippuric acid in the urine and may outweigh the alkalinity of the ash of those fruits

SUMMARIZING this chapter we may say

1 The mineral elements which concern us most are calcium, iodine, iron, and phosphorus

2 There is evidence of widespread lack of the three first in the diet of Great Britain if the usual estimates of the daily needs are accepted Elsewhere, e g in India and China, the lack is still greater

3 There is no reason, even in cases of poverty, why these needs should not be met

4 A balance of acid producing and alkali producing foods is essential only when the kidney has difficulty in secreting acid or alkali

[1] YEH and ADOLPH (1938) *Chin Journ Physiol* 13, 209

[2] To prevent the oxaluria caused by eating spinach and rhubarb all that is necessary is to take some milk or cheese at the same meal BARTLETT (1944) *Lancet*, 2, 574

CHAPTER V

THE FUNCTIONS OF FOOD (*continued*)

(IV) THE SUPPLY OF VITAMINS

In 1912 a revolution in our ideas concerning the indispensable proximal constituents of a diet occurred [1] Up till then it had been assumed that if the diet were adequate as regards Calories protein (with fats and carbohydrates) and mineral elements it would suffice for optimal nutrition Since then we have added one by one indispensable organic catalysts which must be taken in the food either preformed or in a form which can readily be transformed into the specific catalyst These catalysts we call the *vitamins* Intense research upon this subject has given us in the last three decades very clear knowledge concerning the chemical nature of these catalysts and to some extent of the way in which they work. Although finality has not been reached we none the less feel that it is improbable that any similar new surprise will be sprung upon us and that the main lines have been sketched out so that it remains to fill in the details only At any rate looking on the matter from the point of view of practical dietetics we have such a body of knowledge that we can immensely improve the feeding of the individual and the nation by the supply of foods containing the known vitamins

We have spoken of a revolution in our ideas in that sundry organic catalysts in addition to the normal gross substances—proteins fats carbohydrates and mineral elements—are indispensable All revolutions have their seeds in the past and although it was not until 1912 that this particular revolution shook the theory of dietetics to its foundations the first rumours were by then 300 years old long before the dawn of inorganic and organic

[1] For much of the discussion we are indebted to Dr LESLIE H (1938) *Vitamins and Vitamin Deficiencies* 1 Churchill Research Council's Special Report (1932) *Vit Present Knowledge* McCOLLUM ORIENT KEILES *The Newer Knowledge of Nutrition* 5th edn *Chemistry and Physiology of the Vitamins* T (1942) *The Vitamins in Medicine*

chemistry The revolution was the result of the convergence of three lines of research

1 Empirical observations that a food, e g the lemon, is a *specific* against a particular disease

2 The discovery that animals can suffer from such diseases and the foods which are specific in curing them in man are specific for those animals

3 Experimental results of feeding animals with highly purified food stuffs

Empirical Observations —*Scurvy* is a disease which has been known from the time of the Dark Ages It appeared during various sieges in history from that of Acre to that of Kut el Amara in 1917 It accompanied the sailor on his long voyages before the steam era It dogged the footsteps of the Arctic and Antarctic explorers and may even now be seen sporadically in poor people *usually bachelors or spinsters, or in aged people whose diet is at fault.* As long ago as 1601 the East India Company discovered that the disease could be kept at bay or cured by the juice of lemons and oranges This fact was rediscovered by John Woodall in 1639 by Kramer in 1739, and by Lind in 1753 During the potato famine 1845–7 scurvy broke out in Ireland, and in post vitamin days the same has been observed Stefansson cured colleagues sick with scurvy by giving them a diet of (mainly) raw meat

In all this there is more than a hint that scurvy is due to a "deficiency" in the diet and that freshness of the food is in some way or another a specific

Beri beri is a disease of the East which was known in China in 2600 B C Takaki, in 1882, decreased the high incidence of beri beri in the Japanese navy to vanishing point by altering the diet He added fish meat, vegetables barley and condensed milk to a diet consisting predominantly of rice and the disease disappeared Eijkmann, 1890 and 1897, discovered that the disease occurred when the diet was mainly composed of polished rice and could be cured by feeding the rice polishings Here again was a disease caused by a food deficiency Takaki imagined that the deficiency was protein, though Eijkmann's much later observations did not support that interpretation

Pellagra is a disease of maize eating countries e g Spain Italy, Rumania, Egypt and the Southern States of the United States Although a commission appointed in the United States came to the conclusion that defective sanitation was the cause of pellagra, one member of that commission, Goldberger was convinced that it was dietetic In a pellagrinous area those who ate more meat, eggs, or milk escaped while those living on a poorer diet

were attacked Again a deficiency of the diet was inculpated, though Goldberger thought for many years that the cause was a deficiency of first-class protein rather than of a specific catalyst or vitamin

Rickets For a hundred years or more the connection of rickets with a faulty diet was suspected and a specific—cod liver oil—known Schuette writing in 1824, said that "its potency may be due to an imponderable amount of substances which produces marked changes in the body, but cannot be determined by the chemist Cheadle in 1899 wrote that Rickets is produced as certainly by a rachitic diet as scurvy by a scorbutic diet", and Hopkins in 1906 adumbrating the discovery of the vitamins 'In diseases such as rickets and particularly in scurvy we have had for long years knowledge of a dietetic factor They [the errors in diet] are, however, certainly of the kind which comprises these minimal qualitative factors that I am considering'

Thus there arose an idea that some diseases are connected with a deficiency of specific factors, not proteins fats carbohydrates, or inorganic elements, but accessory thereto What the functions of these accessory factors were was not by any means clear Did they counteract the effects of a constituent of the diet present in excess or were they important because of some positive and not negative contribution which they had to make? At first Eijkmann considered that the factor in rice polishings had the function of combating the effects of an excess of carbohydrate in the diet but later developments in his own and other researchers work pointed conclusively to the view that these accessory factors were needed in diet not for any neutralization of the effects of the main constituents but because they catalysed some of the normal functions of the body

Evidence from Diseases in Animals Perhaps the most valuable discovery in dietetics is that animals may suffer from diseases which are analogous with those of the human being Eijkmann in 1890 showed that chickens suffered from a disease which bore a close resemblance to human beri beri and that it could be produced in them as in man by a diet consisting of polished rice and cured in them by rice bran and (in later work) by watery and alcoholic extracts of rice bran Holst and Frolich in Norway trying to extend Eijkmann s work to guinea pigs discovered that the unbalanced diets they gave resulted in a disease that closely resembled human scurvy In post- vitamin days these observations have been extended to other animals and it has been found that the rat can suffer from beri beri or rather a paralysis which closely imitates the paralyses seen in human beri beri from an eye

disease[1] the later stages of which are xerophthalmia and kerato-malacia, and from rickets, the dog from a disease—canine hysteria—which is connected with deficiency of the substance that cures or prevents beri beri, from black tongue or the Stuttgart disease—which has something in common with pellagra and from rickets, the pig from pellagra, and the domestic fowl from rickets as well as beri beri

It is not too much to say that the discovery that animals suffer from the same deficiency diseases as man made the astounding rate of advance of our knowledge concerning the vitamins possible. Without them we should still be debating the cause of the so called deficiency diseases

Evidence from the Feeding of Synthetic Diets Although the scientific and experimental foundation of the doctrine that there are such factors in diet present in minute amounts and essential to life, must always be associated with the name of Hopkins whose work on the subject was begun in *1906* and published in 1912, there had been indications of the possibility of these factors in the work of Lunin, 1888, Socin, 1891, Pekelharing 1905, and Stepp 1909 1911, and 1913 All of these postulated something in natural food other than the known principal ingredients—proteins fats carbohydrates and mineral elements—essential to life. The work of the three earlier investigators was overlooked either because the physiological world was not yet sensitive to the implications of the work or because it was as in the case of Pekelharing published in the Dutch language Stepp s work on the lipoids came at a time when other workers were preparing the way and only helped to confirm the views so admirably stated and so well based on sound experimental work in the classical paper of Hopkins in 1912 He has well been proclaimed "Der geistige Vater der Vitaminlehre

Hopkins fed young growing rats on a diet of highly purified protein *(caseinogen) lard, starch, cane sugar, and inorganic salts* They failed to grow after a few days and then declined in weight till at the 18th or 20th day they weighed no more than at first *If* to the rats on this diet there were given at a different time of day 3 c c of fresh milk or small amounts of an extract from mangolds or of protein free and salt free extracts of milk solids or of yeasts, the animals grew at a rate comparable with the normal growth on a mixed diet Moreover the animals looked fit and were active whereas those on the purified diet did not

Many possible objections to the validity of the conclusions of

[1] According to a communication to one of us (V H M) Hopkins was aware of this and of the cure by green *food well before* 1912

Lunin were ruled out by Hopkins work He showed that the lack of growth was not due to the monotony of the diet or to its lack of palatability or flavour Nor was it due to lack of consumption or failure in absorption The animals which showed the decline in weight and health were consuming more than a sufficient quantity of food to maintain health In fact they often consumed more of the basal dietary than the animals which were growing satisfactorily on the basal diet plus the additions mentioned above

The additions did not supply much energy Even with milk the addition was only 4 per cent of the total energy of the diet eaten, whereas with the extracts of milk or yeast the addition to the energy value of the diet must have been exceedingly small for they worked in "astonishingly small amounts

This work of Hopkins clinched the case for the 'accessory factors' as he termed them, these are substances—not proteins, fats carbohydrates or mineral elements—essential to life Funk christened these accessory factors '*vitamines*' He put forward the theory that scurvy, beri beri pellagra and possibly rickets are caused by the absence from the diet of ' special substances which are of the nature of organic bases which we will call the vitamines The name caught the popular imagination and though it has been shorn of its e because it wrongly suggests that all the vitamines are amines it still holds the field We do not propose to give any account of the floods of research in all countries on vitamins but to jump to modern times and explain the state of affairs to day

There are at least six important vitamins intimately concerned with human nutrition and there may be many more Each as its chemistry is made clear has been or will be given a name which will it is hoped take the place of the provisional letters assigned to them while they were observable only through their activity and not in the isolated form By to day we know the chemistry of most of them and can synthesize them The facts thus discovered make us wish that the name vitamin had not been invented (Accessory factors would have been much better) Chemically speaking it is wrong because some of them contain no nitrogen And practically it is unfortunate because the lay public and others assume that because they have the same name they all behave alike e g that they are all heat labile or that they all occur in the same food [1] Nothing is further from

[1] For example You can kill them vitamins if you only boils em long enough Wholemeal bread only is used for the vitamins We give plenty of fruit and vegetables for the vitamins for which see any popular article on diet and many school prospectuses

the *truth* One food may be excellent for one vitamin
be totally devoid of another . One vitamin may be unstable
whereas another is so resistant that it may be distilled at
temperature It will take many years to eradicate from th
of the public the false ideas sown by the use of the term v

Provisionally as their effects were discovered the vitami
labelled A, B C, etc , after the letters of the alphabet
proved to be not a simple substance but a mixture of sub
and so we have been saddled with B_1 and B_2 B_2 also is a c
but as B_3 and B_4, not to mention B_5 and B_6 had alread
allocated there would have been trouble had not the chem
the component parts become clear As it is names for v
are in a transitional state The old alphabetical nomenclat
not vanished nor is the new completed

Another difficulty must be stated The action of what w
to think of as one chemical substance may be performed
or more substances having similar chemical structures or
configurations in space Keys to pick a lock need not be id
but they must have some general likeness Similarly tw
stances which may cure rickets, though they may not have id
structure will have closely approximating structure Th
illuminating examples are the various substances produc
ultra violet light on the sterols One will cure rickets i
but not in chicken another in chicken but not in rats w
both are curative in man

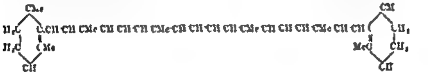
Finally there are substances like choline unsaturated fatty
and amino acids, which enter into the structure of the tissu
none the less have activities like the vitamins These subs
Rosenberg prefers to call vitagens to distinguish them fro
vitamins which he defines as organic compounds whic
required for the normal growth and maintenance of life of an
including man who as a rule are unable to synthesize
compounds by anabolic processes that are independent of en
ment other than air, and which compounds are effective in
amounts do not furnish energy and are not utilized as bu
units for the structure of the organism, but are essential f
transformation of energy and for the regulation of the metal
of structural units

Vitamin A and the Active Carotenoids

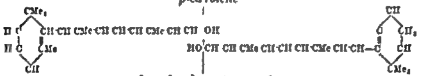
Vitamin A is a colourless alcohol which is taken either i
food as such (e g in liver or liver oils) or as a precursor the
known orange coloured terpene carotene (e g in palm oil c
or green vegetables) The carotene or allied substances su

cryptoxanthin (from cape gooseberries, yellow maize, paprika, etc) echinone (from sea urchins, used as a food around the Mediterranean are transformed into vitamin A in the liver Other yellow pigments such as lutein (or xanthophyll, the yellow colouring matter of eggs) and zeaxanthine (one of the pigments of maize) cannot be so converted All the carotenoids are not equally valuable Thus β carotene is the most active, having apparently half the activity of preformed vitamin A while α and γ carotene have less

We might expect β carotene to produce two molecules of vitamin A It is symmetrical and it conceivably could be split into two equal halves and the adjacent ends oxidized to an alcoholic group, thus



β-carotene



2 molecules vitamin A

But feeding experiments seem to show that molecule for molecule carotene has only half the effect of preformed vitamin A This discussion is not so academic as it may seem because in the tables of vitamin values the figures are sometimes based on feeding experiments (biological assay) and sometimes on chemical estimates of the carotene content In using these tables if only carotene estimations are available the figure given should be halved We judge foods by their vitamin A effect not by their content of carotene and we compare them with each other through the international standard which, however is a highly purified sample of β carotene 0 6 microgrammes[1] of this standard is the *International Unit* When 100 grammes of a given food is equivalent in its vitamin A activity to say 6 microgrammes of the international standard we say that 100 grammes of this food act as if it contains $6 - 0\ 6 = 10$ International Units of vitamin A

Vitamin A is soluble in fats and fat solvents (whence its old name Fat-soluble A) and therefore in medicinal paraffin It gives an

[1] 1 microgramme or 1 γ = 1 thousandth of a milligramme i e 1 millionth of a gramme

intense blue colour in combination with antimony trichloride and also has a characteristic ultra violet spectrum Both vitamin A and carotene are insoluble in water and are therefore not washed out of food stuffs by boiling or steaming Though both are susceptible to oxidation at room temperatures there is little evidence that vitamin A is destroyed by cooking [1] even by such drastic processes as shallow frying, roasting, or pastry making, where the medium in which the vitamin is carried comes into contact with very hot air Canning does not destroy it, nor does it disappear from the milk in a milk pudding Kon states that there is no loss when milk is dried [2]

The body has some difficulty in absorbing carotene, though not so much with vitamin A This is especially marked when fat absorption in the small intestine is deficient as in jaundice cœliac disease and steatorrhœa Medicinal paraffin oil cuts down the absorption of carotene and to a less extent of vitamin A Consequently it is best to take that medicament the last thing at night, as long as is possible after the meals containing vitamin A or its precursor

The subtlest test for deficiency of vitamin A or its precursor is a measure of ability to see in light of low luminosity In the retina, or rather just behind it, is a layer of cells which manufacture a pigment rhodopsin which sensitizes the rods of the retina The rods are used for vision in dim light The pigment is bleached in bright light and has to be regenerated when the eye is adapted to the dark As this pigment is a compound of vitamin A and protein the power to adapt to darkness i e the power to regenerate this pigment, must depend on the presence of vitamin A in the blood Consequently a measure of our power to see in the dark (which fortunately can be obtained with some approach to accuracy)[3] is a *measure of our saturation with vitamin A* Many workers in the United States Scotland England and Belgium are satisfied with the accuracy and constancy of this test, though others prefer scepticism

At a greater stage of deficiency night blindness, or complete inability to see in the dark occurs This trouble was described in Ebers Papyrus (*1500* B C) and in *Jeremiah* xiv v 5 6 [4] and is still present with us and not only in Newfoundland Labrador China Brazil, and the Dutch East Indies, but in England [5] Later follows the appearance of Bitot s spots, then xerophthalmia and

[1] BOAS FIXSEN (1938–9) *Nut Abs and Rev* 8 281
[2] KON (1941) *Nature*
[3] MAITRA and HARRIS (1937) *Lancet* 2, 1009 See also HARRIS and ABBASY (1939) *Lancet* 2, 1299 1355
[4] their eyes did fail because there was no grass
[5] SPENCE (1931) *Arch Dis Child* 6, 19

keratomalacia The two last are due to microbic invasion of the conjunctiva of the eye and the cornea If the keratomalacia is not arrested by a satisfactory diet the cornea perforates and total blindness ensues In India to-day it is the chief cause of preventable blindness in children As many as 2 per cent of the children in Ceylon are blind as the result of obtaining too little vitamin A That microbes can effect a lodgement in the eye is due possibly to two things, (i) a loss of the lysozyme a substance in the tears which digests microbes and (ii) degeneration of the epithelium covering the eye

Structures of epithelial nature all over the body degenerate as the result of deprivation of the body of vitamin A Thus the linings of the respiratory tract and the urogenital tracts keratinize and are more susceptible to bacterial invasion The skin itself alters its nature Babies are more likely to suffer from mild skin eruptions (Helen Mackay) In Ceylon [1] and Kashmir [2] an inflamed and coarsened condition of the skin (toad skin phrynoderma) is accounted for by a deficiency of vitamin A in the diet

Finally, there is incoordination of the growth of the bones of the skull and the spinal column, so that they encroach on the nervous system and damage the sensory tracts Vitamin A by regulating the activities of bone cells coordinates the adjustment of bone and nervous system growth [3]

As a result of this degeneration in epithelial structures and in *afferent* neurones it is not astonishing that this vitamin was at one time termed the anti infective vitamin Afferent nerves have a trophic effect on the epithelia Degenerate epithelia can be attacked by microbes Diseases of the epithelia and glands—abscesses broncho-pneumonia, stone in the kidney and bladder puerperal pyrexia—are more common in animals and human beings when the diet is deficient in vitamin A But although this vitamin, by preserving the epithelia protects from disease once the disease has got a hold exhibition of the vitamin does not necessarily shorten the attack It will certainly clear up a xerophthalmia, but it has no effect on a widespread infection

Like all the other vitamins, vitamin A and its provitamin, are rather erratically distributed among food stuffs The chief sources are fish liver oils, mammalian liver fats fish body oils dairy foods

[1] NICHOLLS Quoted by HARRIS (193.) *Vitamins* O U P

[2] WILSON (1939) *Lancet* 1, 1019

[3] MELLANBY E (1944) *Proc Roy Soc B* 132 28 WARKONY NELSON and SCHRAFFENBERGER (1943) *Am Journ Dis Child* 65 882 quoted in *Lancet* (1944) 1, 316 suggest that hare lip and cleft palate may be due to vitamin A deficiency

and green and yellow vegetables. As figures are now available for the vitamin A, or provitamin A content of foods it is reasonable to let the figures speak for themselves with one proviso: that they be taken more as "illustrations than arguments" Foods vary so much from time to time and place to place and from investigator to investigator that we cannot take the tabulated results in more than an impressionistic way. Most of the figures will be taken from Roscoe and Fixsen,[1] but other estimates are included

VITAMIN A CONTENTS OF FOODS, I U PER 100 GRAMMES (or about 3½ oz)

CEREALS	Yellow maize	300–900	Carotene estimations	
	Whole wheat	100–460		
	Wheat germ	650	(biological assay)	
DAIRY PRODUCTS				
	Butter	1130–3590	Biological assay	
	Cheese	1100–4000		American figures
	Cheddar from winter milk	550		English
	„ summer „	1440		„
Eggs	Yolk	8000		or 1200 per egg
	Whole egg	700	Spectrophotometric assay	350
	„ „	1000[2]	„	„ 500
Milk	Jersey, winter	30	Biological assay	170 per pint
	summer	690		3910
	Mixed pasteurized			
	winter	60		340
	summer	540		3060
FISH AND FISH LIVER OILS				
	Herring fresh	141	Mean of several methods	40 per oz
	canned	28		„ [3]
	Cod liver oil	10 000–400 000	Biological assay	3500–14 000 per teaspoonful
	Halibut liver oil	3 000 000–36 000 000	„	1200–14 000 per drop
FRUITS	Apricots fresh	1800–2300	Carotene estimations	
	dried	5000–5500		
	Nectarines	720		
	Orange juice	300–400		
	Peach (yellow)	760		
	Tangerine orange	690		
LIVERS	Cows Winter	5300–45 000	Summer	3600–30 000
	Heifer	1900–12 000		7500–37,500
	Ox	600–11 000		1700–25 000
	Sheep	30 000–60 000		19 000–82 500

[1] ROSCOE and FIXSEN (1937–8) *Nut Abs and Rev* 7, 823 and (1939–40) 9 795

[2] *Nutritive Values of Wartime Foods* 1945

[3] BACHARACH *et alii* (1942) *Brit Med J*, 36, 34

VEGETABLES				
Beans, green tinned and strained	—		950	Biological assay
Cabbage	—		900	"
Carrot	2000–13 200	Carotene estimations	1000–6 00	"
Green peas				
tinned	139 2000		700	
Spinach				
fresh	2630–49 000		13 000	
tinned and strained			12 230	"
Sprouts	210–650		—	
Tomatoes	14 000–30 000		3000	
tinned and strained	—		4300	

In these tables only outstanding figures among the various types of foods are given It will be seen at a glance that the cereals are negligible sources, only yellow maize being of much value[1] It is interesting to note that white maize with no carotene is preferred to yellow in making the hominy porridge (grits in the Southern States) and among poultrymen in this country another illustration of the passion for whiteness in foods as against colour

Fruits again, are of little value only yellow fruits having useful amounts

The outstanding sources of vitamin A are the dairy foods mammalian livers and fish liver oils vegetables having with the exception of carrots spinach and tomatoes only useful amounts

The carrot since it contains very considerable amounts of carotene was perhaps too well advertised by the Ministry of Food in the second year of the second World War But despite the fact that the body has difficulty in absorbing the carotene from the carrot especially when eaten raw it will always be a useful source of vitamin A activity Tomatoes, which we have placed among the vegetables following normal usage though they are fruits are more valuable for vitamin A activity than for vitamin C This activity is due not to the carotenoid pigment lycopene but to β carotene the colour of which is masked by the intense red of the lycopene Attention is called to the large amounts in spinach among the green vegetables

A note is essential on the dairy products These show extra ordinary variability depending on the time of the year This is due to the fodder of the animals The figure is usually at its lowest ebb in February and March and rises to its maximum in

[1] It is probable that the vitamin A content of whole wheat has been overestimated see the M R C War Memorandum 14 *Nutritive Values of Wartime Foods* 1945

May and June when the flush of new grass increases the carotene intake There is a bigger seasonal variation of the carotene in the milk than in vitamin A[1] Stall fed cows are bound to give a milk with a lower vitamin A activity than ones fed on green grass though if dried grass replaces hay feeding in the winter it may result in winter milks having a higher figure than hitherto Naturally this fluctuation in the vitamin activity of milks is reflected in the butter and cheese made from them Winter butters have much less activity than those of early summer Butters from Australia and New Zealand have a higher average than those from England and Scotland for green fodder is available for much longer periods

Cheese being usually made from surplus summer milk has a good vitamin A activity *Most of the figures quoted by Fixsen and* Roscoe are of American origin and run from 1100–4000 per 100 grammes (310–1130 per ounce) according to the make, Camembert, Danish Blue and Rocquefort being the highest Figures from the National Institute for Dairy Research, still unpublished but which we have kind permission to quote, are as follows Cheeses made from summer milk give figures of 1440, 1410 and 1850 per 100 grammes for Cheddar, Cheshire and Stilton respectively For similar cheeses made from winter milk the figures are 550, 530 and 620 These work out at 418 I U per ounce for summer Cheddar and at 156 I U per ounce for winter milk Cheddar

As the transformation from carotene to vitamin A almost certainly takes place in the liver in mammals we should expect liver to contain large amounts and to show the same fluctuation with the seasons *This is so The figures quoted in the* tables are those of livers from the Cambridge Co operative Society[3] These figures, which are by no means so spectacular as those quoted from American sources, do, however, show the great value of liver in supplying vitamin A in the diet An ounce of liver may easily supply 1000 I U and maybe 10 000 Sheep's liver, even in the winter can supply 10 000 to 20 000 I U per ounce Since vitamin A can be stored, a helping of liver might supply a whole week s ration of vitamin A

Fish body oils are sometimes claimed to have large amounts but the work of Bacharach[4] and colleagues has shown that for the English herring this is not true In case of need, fish liver oils are the standby for vitamin A therapy and will always remain the chief source of concentrated supply

[1] HEILBRON and GILLAM (1937) *Nature* 139, 657
[2] MOORE (1930) *Biochem J*, 24, 692
[3] MOORE and PAYNE (1942) *Biochem J* 36, 34
[4] *Brit Med J* (1942) 2, 691

Amount of Vitamin A Required Though there is general agreement about the average amount of vitamin A needed per day it must be recognized that individual needs may show the widest variations The Americans put the figure at 5000 I U for the adult man or woman, 6000 for the pregnant woman and the adolescent boy, 8000 for the nursing mother 5000 for all girls over 13 years of age and for boys from 13-15 Children under 1 they estimate need 1500 I U and the figure rises by steps to 4500 for those between 10 and 12 These figures of the National Research Council appear high Booher in the United States puts the figure at 3000 for the adult Stickling at 4000, the League of Nations recommends 5000 for the pregnant and nursing woman This diversity of figures suggests that we do not know the best figure nor do we know how people vary in their requirements It does not follow that what is enough for one person is enough for another For example not all people are alike in the case with which they can be made night-blind by deprivation of vitamin A They may vary in their powers of remanufacturing visual purple, or, what is much more common they may vary in their powers of absorbing fats and therefore presumably vitamin A and carotene from the small intestine

This problem of availability appears in the discussion of every "nutrient" the body takes Are all the Calories from this or that food available? We know that they are not If the food is indigestible a considerable fraction goes unabsorbed (e g high melting point fats), if there be much roughage present a smaller percentage of the food is absorbed than when there is little or none if purgatives are taken more calorigenous material is unabsorbed, if there be diarrhoea or dysentery the same is true Proteins as they occur in the foods eaten have different availabilities according to their digestibility and to the accompaniment with other substances notably roughage We have seen in the discussion on mineral elements that they too have different availabilities according to the form in which they are presented the presence of phytates and oxalates the motility of the gut and, probably, the secretory activity of the stomach (A hypochlorhydria will probably make the calcium and iron less available) So too when we turn to the vitamins we shall find the same considerations applicable Some alimentary tracts will be able to extract more of the vitamins from the food within them than others To take an extreme example some of the symptoms of sprue and the other dysenteries which beset the prisoners in Italian and Japanese prisoners of war camps may have been more due to vitamin deficiencies (particularly of the B complex) the result of defective

absorption, than to the disease itself[1] And it may easily be the case that absorption of vitamin A or its precursors may be upset by excessive mobility of the gut, by the use of purgatives and especially by the use of medicinal paraffin oil[2] Consequently no hard and fast rule can be laid down concerning the vitamin A needs of any individual Prisoners eating the same prison diet in Ceylon reacted to it differently Some showed no signs of dietary deficiency others showed avitaminosis A (phrynoderma 55 per cent night blindness 30 per cent and 1 7 per cent kerato malacia) and still others showed avitaminosis B (neuritis, stomatitis and scrotal dermatitis)[3] Clearly no man's need is exactly the same as another s Consequently, though we may accept the figures of 3000 to 5000 I U units a day as being a satisfactory intake of vitamin A, we must expect exceptions

What classes of people attain this level? According to Crawford and Broadley[4] none, even in the AA class achieve the National Research Council s level, the AA and the A class only—well to do people—achieve 4000 I U per day In 1938 probably all classes with an estimated weekly income per head of 43 shillings attained 3000 I U per day Investigations by the pupils of one of us (V H M) into the dietaries of various schools of a charitable nature sometimes showed a marked deficit of vitamin A compared with even the low standard of 3000 I U per day Against the American figure the deficit was always much greater being 30 to 50 per cent below At one well fed school, the quota of vitamin A was attained only because the children had cod liver oil each day, otherwise there would have been a serious deficit

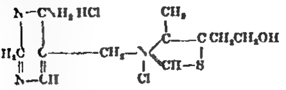
And yet even the American estimated need is not too difficult of achievement In summer it is easy—a diet containing milk, butter cheese and green vegetables makes it certain In February, March and April perhaps it is not so easy, and recourse should be had to reinforcing fish sauces with cod liver oil where it is undetected or to liver liver pâtes or liver sausage Probably it is wiser in winter to keep to the standardized margarines rather than butter which by the nature of its raw material cannot be, or has not been up to the present standardized

Vitamin B_1

After intensive work in Dutch British Japanese, and American laboratories, a crystalline substance was obtained from rice bran or yeast in quantities which could be submitted to chemical analysis

[1] BLOOM (1944) *Lancet* 2, 558 630 [2] *Lancet* (1944) 2, 381
[3] NICHOLLS (1944) *ibid* 1, 630 [4] *The People s Food* 157

The result of the analysis pointed to the following structure, which was confirmed by synthesis [1]



This substance consists of a pyrimidine ring (left) which is of frequent occurrence in substances interesting in biochemistry (e g nucleins uric acid, caffeine) and (right) a thioazole ring which is unique in biochemistry though not in commercial chemistry As this vitamin contains sulphur Williams suggests the name thiamin for it We should probably prefer to write it 'thiamine Donath had suggested 'aneurin in the days before its structure was known

Vitamin B_1 is very soluble in water, and consequently some 50 per cent goes into the surrounding fluid when fruits and vegetables are boiled However, potatoes boiled in their skins lose only 10 per cent of their vitamin B_1 whereas peeled and boiled they lose 25 per cent [3]

This vitamin is somewhat sensitive to high temperature, though at the temperature of boiling water the loss by decomposition is negligible At higher temperatures, however, the loss is much greater, consequently foods more particularly meats and fish, which have been canned and 'processed at a high temperature may have suffered very considerable loss For example Spruyt and Donath found that puffed rice which is exposed to 15 atmospheres pressure at 150 to 160° C, is devoid of vitamin B_1 [2] Losses up to 80 per cent have been reported when meat is canned Consequently, although we need not take into account the loss caused by the ordinary processes of cooking we should not rely upon canned foods for our vitamin B_1 Condensed milk, however, is free from this stricture There is no loss of B_1 during the baking of bread made with yeast, but baking powder apparently destroys the B_1 in the flour and soda destroys it in soda cakes and scones The vitamin is stable in the presence of acid but not in that of alkali

Vitamin B_1 is however sensitive to sulphite even when the medium is acid, and destruction is quite rapid at p_H 6 6, the acidity

[1] WILLIAMS and SPIES (1938) *Vitamin B_1 and its use in Medicine* The Macmillan Co WILLIAMS (1936) *Journ Amer Chem Soc* **58**, 1063 WILLIAMS and CLINE (1936) *ibid* 58 1504

[2] BAKER and WRIGHT (1935) *Biochem Journ* **29**, 1802

[3] Quoted by BOAS FIXSEN (1938-9) *Nut Abs and Rev*, 8 281

of milk Sulphite is permitted in sausages in this country to preserve them, though the fact must be declared Pork contains a comparatively large amount of vitamin B_1, but as sulphiting results in appreciable loss of the vitamin we must not count on pork sausages as an important source of that vitamin

When vitamin B_1 is markedly deficient in the diet, beri beri occurs This disease is of three types, (i) "Dry," when the main symptoms are neuritis and paralysis, (ii) "Wet," when they are mainly serous effusions and œdema, and (iii) "Fulminating or "acute" with sudden onset of cardiovascular symptoms Infantile beri beri is nearly always of the last type

As a diet even in the Orient, is never totally deficient in vitamin B_1, the onset of the disease is insidious It starts with fatigue, sensations of heaviness and stiffness of the legs, and inability to walk long distances Then come headache loss of appetite dyspepsia, dizziness, and slow heartbeat And last sensory and motor paralyses (starting first in the lower extremities) and thence progressing up the body The early symptoms are sometimes seen in this country in people on a diet for peptic ulcer and indeed progression to later stages

In a study of symptoms seen in a group of volunteers at the *Mayo clinic*[1] when they were restricted to a diet containing 0 4–0 45 milligramme thiamine (133 to 150 I U) per day cardiac symptoms were a prominent feature Pulse rate was slow when resting abnormally fast on exertion Cardiac sounds were faint and there was marked sinus arrhythmia Anæmia, hyperchromic and macrocytic in type was present The basal metabolic rate was lowered 10 to 35 per cent Intolerance to cold was observed The subjects became depressed irritable, quarrelsome and fearful, inefficient in work and unable to concentrate They complained of soreness of muscles fatigue poor appetite insomnia headache, backache gastric distress, paræsthesia, and intolerance to noise and pain These symptoms disappeared when, unknown to the subjects the intake of vitamin B_1 was increased

In animals there is a widespread destruction of sensory and motor nerves but this must be a terminal phenomenon Paralyses in animals respond so rapidly to a dose of vitamin B_1 that repair of nerves would be impossible in the time What is wrong in the earlier stages of beri beri is an upset of carbohydrate metabolism in the central nervous system Once the central nervous system is thrown out of gear it seems probable that all the other symptoms of avitaminosis B_1 occur as the result of its incapacity

It has always been suspected that carbohydrate metabolism is

[1] WILLIAMS and MASON (1941) *Proc Mayo Clinic* 16, 433

probability of variability Persons on exactly the same ... in the same circumstances may need different amounts ... absorption in different persons may be different (3) There ... doubted relation between Calorie output and the need for ... B_1 and the amount needed may vary more with the amount ... ories obtained from carbohydrate than from the rest of the ... Increase of Calories in the food or of poisonous substances ... concomitant increase of vitamin B_1 may precipitate an ... of neuritis (Alcoholic neuritis and possibly the neuritis of ... are connected with this) (4) Fat and more particularly ... ty acids with 6 ... or 10 carbon atoms reduce the need for ... in B_1—another testimony to the value of milk and butter in the ... (5) The microbic flora of the gut and the thiamine they hand ... to their host may vary from time to time and person to person ... The best thing we can do at the present time is to give estimates ... various people and leave the matter with the warnings (i) that ... figures are provisional guesses and (ii) that if the reader feels he ... taking sides he should beware of prejudice

...all	10 I U per 100 Calories i e 300 I U for a 3000 Calorie diet.[1]	
...on	150 I U the minimal protective dose for Orientals	[2]
	200 I U safe "	[2]
...mmond et ...	200 ...00 I U the minimal safe dose for Europeans	[3]
...ms and ...	333 667 I U	[3]
...	300-600 I U	[4]
...m... and ...mmer	450-7..0 I U	[5]
...od	300 I U	[6]
...ms and ...on	166-2... I U ... 1000 Calories of the diet	[7]

...oted by ... and He... OUP
...ted by W... B_1 The Macmillan
...RUMMOND ... 1 SINGER (1938)
Hygiene 38
...min B_1
...mins and ... CUP
...MER and ... *and Vitamins*
...ns Green &
...WOOD (1939 ... *the Nutrition*
...ations ... Geneva
...1 in Great ...
...AMS and

		Units per gramme	Units per lb
CEREAL PRODUCTS			
BREAD	National Wheatmeal 85 per cent extraction	0 6–0 7	272–317
	'Plain Scottish white	0 24	109
	" 75 per cent extraction	0 24	109
	" 70 per cent extraction	0 25	113
	" 60 per cent extraction	0 16	73
	White	0 12–0 30	54–136
	White with malt	0 27 and 0 35	123–159
	Germ of wheat	0 80–1 70	364–772
	National Flour	0 8 –0 85	364–387
	Oatmeal (breakfast)	1 4	635
	Rye bread (rye ½ white flour ½)	0 45	220
	Wholemeal	0 75–1 30	341–590
FISH	These have from 0 3 to 0 6 per gramme (the last figure being for herring roe) or 139 to 377 per lb		
FRUITS	Fresh	0 3 –0 5	136–227
	Dried	0 75–1 0	341–454
	Nuts	0 9 –2 0	408–907
MEATS	These all contain about 0 5 per gramme or 227 units per lb with the exception of those from the pig which have much higher amounts e g		
	Bacon fried	2 8–4 8	
	Ham boiled	2 2	1021
	Kidney pig raw	3 4	1563
	Pork roast lean	3 2	1486
			per pint
MILK	Raw and pasteurized	0 23	130
	Sweetened Condensed	0 4–0 6	
PROPRIETORY ARTICLES			per lb
	Bemax Wheatgerm	15 0	6820
	Marmite	30	13 610
VEGETABLES	These also contain from 0 3 to 0 6 per gramme with the exception of the pulses (1 2–2 1) even canned peas having 1 2 per gramme or 556 per lb		

The *amount needed per day* is a matter of some discussion, and there is an unacknowledged tendency among those who believe in the virtues of roughage and of wholemeal bread to raise the estimate and among those who depreciate these virtues to keep it low Much too much emotion has crept into a discussion which should be coldly scientific

A hard and fast estimate cannot be given because (1) There

is the probability of variability Persons on exactly the same diet and in the same circumstances may need different amounts (2) Absorption in different persons may be different (3) There is an undoubted relation between Calorie output and the need for vitamin B_1 and the amount needed may vary more with the amount of calories obtained from carbohydrate than from the rest of the food Increase of Calories in the food or of poisonous substances without concomitant increase of vitamin B_1 may precipitate an attack of neuritis (Alcoholic neuritis and possibly the neuritis of pregnancy are connected with this) (4) Fat and more particularly the fatty acids with 6 8 or 10 carbon atoms reduce the need for vitamin B_1—another testimony to the value of milk and butter in the diet (5) The microbic flora of the gut and the thiamine they hand over to their host may vary from time to time and person to person

The best thing we can do at the present time is to give estimates by various people and leave the matter with the warnings (i) that the figures are provisional guesses and (ii) that if the reader feels he is ' taking sides he should beware of prejudice

Cowgill	10 I U	per 100 Calories i e 300 I U for a 3000 Calorie diet.	1
Van Veen	150 I U	the minimal protective dose for Orientals	2
	200 I U	" safe "	2
Drummond et alii	200-500 I U	the minimal safe dose for Europeans	2
Williams and Spies	333-667 I U	" " " "	3
Harris	300-600 I U	" " "	4
Plimmer and Plimmer	400-750 I U	"	5
Bigwood	300 I U	"	6
Williams and Mason	100-333 I U	per 1000 Calories of the diet	7

[1] Quoted by CALLOW (1938) *Food and Health* O U P

[2] Quoted by WILLIAMS and SPIES (1938) *Vitamin B₁* The Macmillan Co DRUMMOND BAKER WRIGHT MARRIAN and SINGER (1938) *Journ Hygiene* 38 356

[3] *Vitamin B₁* (1938) The Macmillan Co

[4] *Vitamins and Vitamin Deficiencies* (1938) Vol I C U P

[5] PLIMMER and PLIMMER (1938) *Food Health and Vitamins* Longmans Green & Co 8th edn

[6] BIGWOOD (1939) *Guiding Principles for Studies on the Nutrition of Populations* League of Nations Health Organization Geneva Published in Great Britain by Allen & Unwin.

[7] WILLIAMS and MASON (1941) *Proc Mayo Clinic* 16, 433

All these figures are given by people who have been in close touch with work on vitamin B_1 or have actually been responsible for research work on it The National Research Council of the U S A has gone into greater detail and estimate as follows

			I U
Man,	70 kg	sedentary	500
		moderately active	600
		very active	767
Woman	56 kg	sedentary	400
		moderately active	500
		very active	600
		pregnant	600
		nursing	767
Child	Under 1 year		133
	1–3 years		200
	4–6		267
	7–9		333
	10–12		400
Girls	13–15		467
	16–20		400
Boys	13–15		533
	16–20		667

We are aware that there is a big margin between the amount which will prevent beri beri and the amount which is optimal This margin exists because we have no accurate way yet of gauging the optimal figure Are the lack of appetite, lassitude dyspepsia, constipation and the many other symptoms of the patent medicine advertisements, an indication that we are not obtaining sufficient vitamin B_1? Who can tell? It may be so On the other hand the apparent disappearance of these symptoms on increasing the intake of vitamin B_1 may have the same origin as the disappearance of symptoms after taking a patent medicine

It will be shown later that a diet which is planned on the usual British convention and at the same time is satisfactory as regards calcium, iron and phosphorus, and vitamins A C, and D will contain about 600 I U vitamin B_1 and is therefore presumably safe For the rest we should advise increasing the intake in pregnancy and lactation by the use of marmite Bemax and other B_1 preparations (see pp 696–7) and, after investigating the diet, trying the effect of similar additions in any neuritis[1] or even in the vague malaises fatigues and dyspepsias which are so common The disappearance of symptoms after taking vitamin B_1 must however, be critically and scientifically examined Investigations by pupils of one of us

[1] THEOBALD (1936) *Lancet* **1**, 834 YUDKIN (1938) *Lancet* **2**, 1347 PRICE (1938) *Lancet* **1**, 831

(V H M) of the diet of schools of the public assistance type show that the probable intake was in all cases well above the American figure—is highly satisfactory This is a tribute to national wheatmeal bread of 85 per cent extraction It is indeed very difficult in this country to go without the quota of thiamine when eating national wheatmeal bread One of the problems of the future is to get vitamin B_1 into the loaf and yet preserve that whiteness ' which is the desire of the millers bakers and populace

Vitamins of the B_2 complex

Undoubtedly the vitamin effect first studied as the result of Eijkmann and Grijns s work was that of thiamine and it was assumed that there was one single vitamin water soluble B in the bran yeast liver and other foods investigated for this action But as work progressed it became clear that there was not one vitamin only but many With the progress of research the vitamins in these food stuffs have extended their ranks like the oysters in a famous poem Often the clues to their existence were given by microbiology Yeasts were stimulated to grow by such and such an extract but not by others Microbes such as lacto bacillus casei, are very exacting and specific in their demands for vitamins Some can synthesize one and not others And by collating this work with experiments on vertebrates a long list of vitamins essential for vertebrates has been established They are usually spoken of as the B_2 complex—an indifferent term How far they all are important in human dietetics as opposed to dietetics for microbes is at present uncertain for, though perhaps essential for human metabolism they may be of little importance in dietetics because (i) they are so widespread among foods and so little is needed per day that no one should ever lack them from the diet and (ii) the microbes of the alimentary tract synthesize the wanted factors and hand them over to their host This may at times happen even with thiamine [1] They may have importance in medicine as apart from dietetics because sulphonamides given by mouth check the activity of the microbes inhabiting the gut and may perhaps induce vitamin deficiencies

Of the different moieties of the ' vitamin B_2 complex we name riboflavine, nicotinic acid (or nicotinamide) pyridoxine biotin paraminobenzoic acid pantothenic acid inositol and folic acid There are others We are certain that riboflavine and nicotinic acid (or nicotinamide) among these are important in human dietetics We know now that biotin is essential for human metabolism but unless huge amounts of raw eggs are eaten it is

[1] Quoted by ROBINSON (1944) *Chem and Ind* 386

cannot be the case for teetotallers suffer no more than beer drinkers, and it cannot be due to tea drinking because the 2 oz ration of tea per week can by no means cover the supposed needs of the body [1]

Recommendations by the National Research Council of the U S A are that adult males should have 2 2 to 3 3 milligrammes per day according to activity, women 1 8 to 2 7, and 2 5 and 3 0 in pregnancy and lactation respectively, girls 2 0 around puberty and thence on 1 8, boys 2 4 at puberty and 3 0 from 16–20, and children rising in equally graded steps from 0 6 to 1 8 milligrammes These amounts are almost certainly in excess of what people actually obtain in Great Britain, and there is evidence that less will prevent the appearance of symptoms Thus when the diet in a camp in North Africa contained on the average 1 6 milligramme of riboflavine per day no stomatitis was seen whereas when the riboflavine content of that diet sank to about 1 0 milligramme it appeared in 16 per cent of the subjects The stomatitis could be cured by riboflavine but not by nicotinic acid [2] Macrae and others [3] have shown that when the average intake in the R A F messes is 1 9 milligramme no signs of a flavinosis occur Consequently we may assume that the minimal dosage is between 1 0 and 1 6 milligramme per day and in view of the immunity of the British Isles to aflavinosis pay little attention to the riboflavine content of our diet If the diet is sound as regards vitamins A and B_1, it is probably sound as regards riboflavine [4]

In the subjoined table a few estimates of the riboflavine contents of foods are given to two significant figures Later work may alter these figures as the methods of estimation improve They are taken from many sources but the majority are from Fixsen and Roscoe [5]

It is unfortunate, perhaps, that this table lends itself to propaganda for proprietary articles which the firms concerned will not fail to exploit Within a short time of the publication of the relevant figures attention was called to the riboflavine content of a pint of beer in the House of Commons but no one thought to mention the all round values of cheese and milk as compared with beer

[1] Two ounces of tea would yield 73 microgrammes per day

[2] JONES GREEN ARMSTRONG and CHADWICK (1944) *Lancet* 1, 720

[3] MACRAE BARTON WRIGHT and COPPING (1944) *Biochem Journ* 38 132

[4] BIGWOOD (1939) League of Nations Health Organization Publication 88 No basic diet can be made up which is devoid of lactoflavin

[5] BOAS FIXSEN and ROSCOE (1937–8) *Nut Abs and Rev* 7 823

RIBOFLAVINE CONTENT OF FOODS IN ORDER OF MAGNITUDE

mg per 100 g		mg per 100 g	
3.3	Marmite	0.20	Ham
[illegible]-3.6	Baker's yeast	0.20	Mutton chop
[illegible]3	Pig's liver	0.19	Brisket of beef
1.8-3.0	Brewer's yeast	0.17	Cheese, whole milk
1.6	Ox liver	0.14	Turbot
1.6-2.3	Meat extract	0.13	Pickled beef
1.5	Meat juice, concentrated	0.10-0.42	Herring
		0.10-0.[illegible]0	Nuts
1.3	Skimmed milk powder	0.10	Honey
1.06	Bemax	0.07-0.32	Mutton
0.88	Tea	0.07-0.19	Corned beef
0.53	Herring roe, soft	0.06	Spinach
0.46	Lean beef	0.05-0.31	Cod
0.41-0.69	Sardines	0.05-0.17	Beer, English war time
0.39-0.41	Cheese, skimmed milk		
0.30-0.40	Whole milk powder	0.03-0.07	Bread
0.30	Kipper	0.027-0.1[illegible]	Milk

Nicotinic Acid

Quite the most startling advance in our understanding of the working of the vitamin B complex is the discovery of the importance of nicotinic acid or nicotinamide in diet. As already stated, Funk in 1912 put forward the idea that pellagra was due to the absence of a vitamin from the diet. This disease is characterized in its earlier stages by an inflammation and pigmentation of the skin on forehead, cheeks, hands and feet, and in its later stages by diarrhœa and dementia. It is particularly prevalent wherever maize is a staple food and apparently people on the verge of the disease may be pushed over the edge by infection with parasites or a lack of iron.[1] Such parasitic infection is common among the fellahin in Egypt who suffer from pellagra, though it is not the exciting cause.

Dogs suffer from a disease, 'blacktongue,' which for long has been considered to be the same disease, and pigs on a diet consisting largely of maize become very ill with pigmentation of skin and weakness of legs.

Now the heat-stable constituent of yeast, which was originally called B_2, cures pellagra and blacktongue, while riboflavine does not. Therefore it was suggested that a moiety of B_2, which cures dermatitis in rats, B_6, might be essential for man and would cure pellagra. This is not true. The truth was discovered in an odd way.

Funk, in his search for 'vitamine' in rice bran, isolated nicotinic

[1] BIGGAM and GHALIOUNGUI (1933), *Lancet*, 2, 1198.

NICOTINIC ACID CONTENT OF FOODS, MILLIGRAMMES PER 100 GRAMMES

CEREALS AND CEREAL PRODUCTS		MILK	<0 1–0 5
Bread, white	0 5	dried	2 5
„ Wholemeal	1 2	„ skimmed	4 3–15 0
Maize	0 9–1 6 (!)	PROPRIETARY ARTICLES	
Oats, medium	1 0–1 1	Beer	7 0
Rice milled	1 6–2 4	Bemax	6 0
„ parboiled and milled	3 8	Marmite	65 5
Wheat whole	4 7–5 3	Meat extract	37 5–102 5
„ germ	2 7–9 1	„ juice	34 5–61 5
„ bran	5 0	VEGETABLES AND NUTS	
White flour	0 9–1 1	Cabbage	0 3
FISH Herring	2 9–4 0	Carrot	<0 5
White E P	1 7–8 4	Peanut	13 0
FRUITS Apples	<0 5	Potato	1 0–2 0
Tomatoes	<0 5	Soya bean	4 85
MEATS Offal Heart	1 2–8 0	Spinach	1 7
Kidney	3 8–19 4	YEAST (baker's moist)	7 4–12 0
Liver	9 3–46 0	(brewer's ")	9 1–10 2
Tongue	12 8	Extract	47 7–49 7
Muscle	3–18		

in view of the fact that so much skimmed milk has been wasted in Great Britain in the past

It is clear from this table that no one in peace time need go without their ration of nicotinic acid and that even when severely rationed it is possible to attain it The fact that so few cases have been reported during the war of 1939–45 in this country confirms this

The general impression obtained from considering all the three moieties of the vitamin B complex is there is little reason to suspect a deficiency of any one of them in the diet in Great Britain certainly so long as National wheatmeal bread is the bread eaten

Other Moieties of the B complex

We have mentioned biotin inositol pyridoxine paraminobenzoic acid, pantothenic acid and folic acid among the vitamins which may be essential to man They are essential for microbes chicken, mice and rats and therefore probably for man

Biotin has been shown to be essential to man by a somewhat drastic experiment Four volunteers were given sufficient raw egg white to supply 30 per cent of the Calories of their diet This represented the whites of 80 eggs per day Since the avidin of raw egg white combines with biotin and renders it unavailable

[illegible] the intake of [illegible] 3-4 weeks [illegible] pallor of [illegible] [illegible] There were also [illegible] anaemia. The [illegible] [illegible] has been used [illegible] [illegible] but so far no cases of [illegible] have been [illegible]

[illegible] and in foods of [illegible] greatest amount and [illegible] that [illegible] a feral dietary [illegible]

Much the same can be said of the other [illegible] Inositol is found [illegible] green leaves. In cereals [illegible] heart muscle, kidney, liver [illegible] eye) is bound to contain [illegible] may contain a little [illegible]

Pyridoxine occurs in [illegible] and cereals, especially in the bran and the germ. Liver and fish contain moderate [illegible] egg yolks, lettuce and spinach small [illegible] highly purified diet containing no pyridoxine [illegible] paws, snout, ears, tail. [illegible] rats and pigs have epileptiform convulsions and develop a microcytic anaemia. Apparently there is no evidence that man suffers from a pyridoxine deficiency anaemia unless as [illegible] it. It is much too soon to do more than speculate. [illegible] chosen to contain first class proteins, calcium, iron and vitamins A, C and D will cover the need for pyridoxine.

The same is almost certainly true for p-aminobenzoic acid and pantothenic acids. Absence of the former in the [illegible] causes greying of the black fur and it has been used in [illegible] greying of the hair due to nutritional causes. It is [illegible] wide spread in foods and moreover is made by the [illegible] inhabiting the gut, whence it can be absorbed. [illegible] no one, that is, who is not undergoing treatment by sulphonamides—to be without a sufficiency of p-aminobenzoic acid, [illegible] either from food or the microbes of the gut.

Pantothenic acid—its name means that it is found [illegible]

[1] SYDENSTRICKER and others (1942) *J. Amer. Med. [illegible]* [illegible] 1199.

[2] McCANCE and WIDDOWSON (1944), *Nature*, [illegible]

is widely dispersed in food, liver and kidney being the best sources the rest of the offals coming next and finally meat Green plants manufacture it and store it in their seed coats Black treacle is a good source

Folic Acid, which is found in leaves, liver kidney and yeast has become very important clinically It is a condensation product of a pteridine molecule with paraminobenzoic and glutamic acids It cures the anæmia of pernicious anæmia and other hæmolytic hyperchromic anæmias Although so potent in this it does not prevent the neurological complications which may occur coincidently with or independently of, the hæmolytic anæmia It also cures tropical sprue and some kinds of non tropical sprue but not it is said coeliac disease in children [1-6]

Of the remaining portions of the B complex [7] it may safely be said that our needs for them will be covered by a diet satisfactory for the main mineral elements and vitamins

Summarizing the chemistry of vitamin B is mainly that of yeast bran germ liver and leaves and the ferments and coferments of the cell in carbohydrate metabolism Three of these vitamins thiamine, riboflavine and nicotinic acid, are notoriously deficient in the diet of the poor in Asia while nicotinic acid is deficient in the diet of Mediterranean countries and the Southern States of the U S A Riboflavine deficiency is known in the U S A but is rare in Great Britain Though the appropriate vitamin may produce spectacular cures of the deficiency disease presenting itself in the long run it is useless unless the all round nutrition is improved

Vitamin C or Ascorbic Acid

The history of the prevention and cure of scurvy presents many examples of the waywardness of human thought and action It was known as early as 1601 that oranges and lemons kept scurvy at bay, but this was a secret and maintained so in the interests of commerce [8] It was rediscovered by Lind in 1753 It was also

[1] LOPEZ SPIES TOCA (1946) *Journ Amer Med Assoc* 132, 906
[2] MOORE BIERBAUM WELCH and WRIGHT (1946) *Jour Lab & Clin Med* 30 10 1056
[3] DARBY JONES and JOHNSON (1946) *Journ Amer Med Assoc* 130, 780
[4] HARRISON and WHITE (1946) *Lancet* 2, 787
[5] MANSON BAHR and CLARKE (1946) *Lancet* 2, 903
[6] Leading Article *Lancet* (1947) 1, 182
[7] ROBINSON (1944) *Chem and Ind* 370 386 (1947) *Food Manufacture* 22 71
[8] NIXON (1938) *Proc Roy Soc Med* 71, 193 See also BOURNE (1944) *ibid* 37, 512

known in the eighteenth century that sprouted seeds and grain were a preventive and cure (Bachstrom, 1734), and Captain Cook showed that living on the fresh fruits of the lands he visited reduced the cases of fatal scurvy among his sailors to zero But all this was forgotten in the nineteenth century despite the fact that the navy had abolished scurvy by introducing lemon juice into the diet Its occurrence was due it was said, to an altered acid base equilibrium of the body or, later, to the presence of microbes It was not till Holst discovered that guinea pigs put on a diet of oats and autoclaved milk, suffered from a similar disease that an opportunity was given to find out what foods could prevent or cure scurvy We now know that alone of the animals, man, the primates and the guinea pig can suffer from scurvy while the birds cat, dog rabbit and rat do not To-day we are certain that all or nearly all of the symptoms of scurvy are due to the lack of a vitamin which received the provisional name of vitamin C and now has been called by the first person to isolate it ascorbic acid

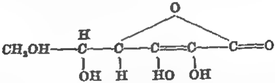
The first symptoms of onset of the disease, apart from the gloom, irritability, fatigue giddiness on standing upright after having stooped, and condemnatory and uncalled for argumentativeness described by Stefánsson—which indeed are common prodromata of most diseases—are soreness of the gums and pain in the joints Later the gums are swollen and painful the teeth become loose in their sockets the pains in the joints on movement become unbearable and the skin shows multiple petechiæ or bruise like patches Possibly the growing pains of the Victorian public schoolboy were a sign of incipient scurvy, possibly too the bouts of nose-bleeding [1]

To-day the disease is rarely seen except on Arctic and Antarctic exploration (and now should never be seen again) during sieges (of which that at Kut el Amara 1917 was the last) and in railway and other engineering construction camps Sporadic cases appear among indigent bachelors and spinsters living by themselves and doing their own housework and catering and it has been seen in young men living at home having a midday meal in a city restaurant and returning in the evening to the warmed up" remains of a meal their parents had in the middle of the day Elderly people too who on account of false teeth and flatulence and other alimentary troubles have given up fruit and vegetables may develop sore patches in their mouths and purpura which are readily cured by a daily dose of orange-juice

[1] FRIEND (1935) *The Schoolboy*

Practically all cases of gastric and duodenal ulcer [1] coming into hospital are woefully deficient in vitamin C, for it is fairly easy to detect a deficit (see later) This deficit is probably the result of omitting acid fruits, salads, and vegetables from the diet on account of dyspepsia, though we cannot entirely rule out the possibility that ulcers may result from a deficit of vitamin C in the diet There is a suspicious peak of incidence of peptic ulcers in late winter and early spring, and guinea pigs on a prescorbutic diet frequently have them (20–30 per cent) No wound heals well if an animal and probably a human being is kept on a diet with but small amounts of the vitamin in it

The elucidation of the chemistry of vitamin C is interesting in view of the international collaboration involved Holst and Frolich Norwegians, started experimental work on animals Zilva at the Lister Institute noted that fresh lemon juice reduced a blue dye called indophenol blue Tillmans and Hirsch in Germany used this fact to discover the age of lemonade " made from fresh lemon " Szent Gyorgyi a Hungarian, discovered a crystalline reducing substance in various plants and one or more animal tissues (notably the cortex of the suprarenal) The dye reducing power of fruits or vegetables seemed to go parallel with their vitamin C activity King in America obtained crystalline vitamin C from lemons and showed it to resemble Szent Gyorgyi's reducing substance Szent Gyorgyi and Svirbely in Hungary tested the reducing substance on scorbutic guinea pigs and cured them Then Szent Gyorgyi discovered a good source of it in paprika and sent a large sample to Haworth at the Birmingham University organic chemistry laboratory, where its structural formula was worked out and the compound synthesized It is



In other words it has the skeleton of a hexose sugar but it is unsaturated It can take up oxygen and also be reduced Szent Gyorgyi christened it ascorbic acid In small doses, say 30 milligrammes a day it prevents most of the symptoms of scurvy But according to Szent Gyorgyi the capillary fragility which gives

[1] HARRIS ABBASY ROY and MARRACK (1935) *Lancet* 2, 1399 ARCHER and GRAHAM (1936) *ibid* 2, 364 BOURNE (1938) *Brit Med Journ* 1, 560

[2] SMITH and MCCONKEY (1933) *Arch of Int Med* 51, 413

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rate destruction

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the ascorbic acid Olliver[1] reckons the loss to be
after 15 minutes and 75 per cent after 90 minutes
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l depot to canteens Pupils of one of us (V H M)
ample, that whereas the vegetables as served at a
led 7 2 milligrammes per helping they would have pro-
nes as much if they had been served as soon as cooked
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may have as much as 60 milligrammes ascorbic acid
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it

and Bottling Owing to the prolonged high tempera
canning and bottling of fruits and vegetables it might
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getables fresh from market gardens can be used for
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tables for feeding soldie the field But the use of
vegetables has in —notoriously in the Civil
U S A —been During the war
y paying due orbic acid oxidase and
ng air from the possil produce
getable having the ascorbic
en cooked such per cent
w value of s very
with those in
nitrogen retain

R (1943)
ER (1936) ibid
BARKER and

dehydroascorbic acid by the nitrite in saliva It will probably be reduced again to ascorbic acid in the reducing surroundings of the stomach and intestine Peeling and keeping potatoes overnight, contrary to widespread belief and statements by authorities, does not deplete the vitamin C [1]

Cooking It has been long known that ascorbic acid is labile to heat, wherefore it has been loosely and inaccurately stated that all cooking destroys the vitamin C value of cooked fruits and vegetables This is far from the truth There is a loss in cooking but this is partly due (i) to the action of the plant's oxidases, and (ii) to leaching of the vitamin into the cooking fluid The oxidase works most rapidly between the temperature of 65° and 85° C Above 85° C it is destroyed The problem then is to ensure that the vegetable is cooked in water which never falls below a temperature of 85° C Obviously if it is put into cold water and brough to the boil, however quickly, the oxidase will bring about th maximum destruction Even if it is plunged into boiling wate in sufficient amounts to lower the temperature of that water belov 85° C destruction of the ascorbic acid will take place In th R A F the vegetables are added in three or four portions on after the other, so that the temperature never falls far belov boiling point [2] Even so, if the proportion of water to vegetabl is high, ascorbic acid is lost through solution in the water This can be obviated by boiling the vegetables in relays, using the water from one lot to boil the second and so on a method used in preserving the ascorbic acid in dehydrated vegetables [3] The Ministry of Food recommends the following treatment to avoid losses of ascorbic acid in domestic cooking A small amount of water is placed in the saucepan and brought to the boil The vegetables, shredded with a sharp knife are dropped in, the saucepan lid put tightly in position and the vegetables cooked partly in the water and partly in the steam above Cooking is completed in about ten minutes Constant attention is needed to prevent them from sticking to the pan and burning

As a result of early work on the influence of alkali on ascorbic acid it has been too readily assumed that the addition of bicarbonate of soda to the water in which greens are boiled—a means of preserving the green colour—will destroy the vitamin C Olliver [4] has shown that the addition of 2-4 grammes of sodium carbonate or bicarbonate to the gallon of water does not destroy vitamin C

[1] MARRACK *et al* (1944) *Lancet* 2, 569
[2] MACRAE (1944) *Proc Nut Soc*, 1, 99
[3] MAPSON (1944) *ibid*, 1, 101 TRECHMAN (1944) *ibid* 1, 103
[4] OLLIVER (1943) *Chem and Ind* 62, 146

-preciably though if the greens are kept hot after they are cooked
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Jams, if the fruits from which they are made contain vitamin C
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Dehydration Vegetables and fruits have long been dried as
method of preserving them Each war revives the scheme for
rying vegetables for feeding soldiers on the field But the use of
ich dried vegetables has in the past—notoriously in the Civil
War in the U S A —been followed by scurvy During the war
1939–45 by paying due attention to the ascorbic acid oxidase and
y excluding air from the 'pack' it has been possible to produce
dried vegetable having 60–80 per cent of the original ascorbic
cid When cooked such vegetables should retain 25–35 per cent
f their raw value of ascorbic acid a figure which compares very
avourably with those in home cooking[3] Dehydrated vegetables
tored in nitrogen retain their qualities for at least a year

[1] Olliver (1943) *Chem and Ind* 62, 146
[2] Olliver (1936) *ibid* 55, 153
[3] Allen Barker and Mapson (1944) *Proc Nut Soc* 1, 153

statement of fact Nor should we accept in Great Britain figures for food commodities obtained and analysed outside these islands Tomatoes grown under the weather conditions prevailing in Great Britain are different as sources of ascorbic acid from those grown in the U S A A banana when submitted to analysis here is a very different fruit from one analysed in the States though both may have come from the same place in the Caribees, and similarly with a green pepper analysed here, or in Hungary or in Louisiana Each country must prepare its own vitamin tables and give the range of values

In the following table the amounts are given in milligrammes ascorbic acid for 100 grammes which as pointed out earlier *is an average allowance of fruits and vegetables Heavy type indicates useful sources*

FRUITS

Apple Blenheim Orange	3	Lemon	*14–66*
Bramley Seedling	**16**	Lime	**32–58**
Cox s Orange Pippin	**2**	Loganberry	**20–48**
Banana	**1–15**	Melon Cantaloupe	**15–53**
Cherry	**3–17**	Orange	**16–99**
Currant (black)	***136–353***	Juice	***28–69***
" *(red)*	***50***	Pear	*1–10*
Gooseberry	**28–47**	*Pineapple*	10–63
Grape	**1–4**	Plum	0 5–5
Grape fruit	**26–65**	Raspberry	**30**
Greengage	0 5–7	Strawberry	**46–77**
Haw	***49–500***	Tangerine	*10–36*
Hip	***10–1870*** [1]	Tomato	13–39

Hips and haws have been included because schoolboys are apt to eat them and the U S S R employ them in the manufacture of antiscorbutic for winter use in the Arctic Circle Moreover during the war of 1939–45 the Ministry of Food has put rose hip juice on the market as a source of vitamin C for infants and children One medium sized orange weighs about 170 grammes and yields about 70 c c juice and therefore from 11 to 62 milligrammes ascorbic acid according to origin South African oranges have the highest titre of the oranges sold in Great Britain We call attention to the enormous amount in black currants and point out the value of

[1] *The figures given are for British rose hips* Scottish and northern grown hips have the highest value Hips from a Turkestan species grown at Kew reached a record figure of 4800 PYKE and MELVILLE (1942) *Biochem Journ* 36, 336

these even when canned, in supplying vitamin C at a time or place where it is difficult to obtain it During the war the standardization of the purées of black currants used for infants and patients with gastric disorders has been in the hands of Olliver, of Chivers & Sons, who first put the purée on the market

VEGETABLES (RAW) USED AS SALADS

Carrot	4	Onion spring	14
Celery	1–6	Peppers	12–330
Cucumber	1–18	Radish	12–20
Endive	19	Tomato	13–39
Lettuce	0 5–22[1]	Watercress	24–76
Nasturtium i e Tropaeolum majus leaves	200–465		

We point out how disappointing carrot, celery and lettuce are, and the possibility of using peppers which are sometimes sold in our big stores in autumn as a source of vitamin C If people would learn to use raw cabbage and raw brussels sprouts and turnips as salad the salad sources of vitamin C could be extended and cheapened e g

Cabbage	20–124	Sprouts	72–146
Cauliflower	19–101	Swede	20–47
Green sprouting broccoli	111–141[2]	Turnip	17–43
Kohl rabi	50		

COOKED FRUITS

Currant (black)	90 } as normally consumed[3]
Currant (red)	23 } as normally consumed[3]
Gooseberry	20 } as normally consumed[3]
Grapefruit-juice	34–50 (canned)
Hip	210 (cooked 12 mins sieved sugar added cooked another 4 minutes)
Loganberry	20 as normally consumed[3]
Orange-juice	29–50 (canned)
Strawberry	solid 10–55, liquid 10–20

[1] English mean figure given as III by OLLIVER (1943) *Chem and Ind* 63 146

[2] American figures WHEELER TRESSLER and KING (1939) *Food Research* 4 593

[3] Figures from OLLIVER *Op cit*

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(ii) the relation of calcium and phosphorus to each other in the diet
(iii) the relation of calcium and phosphorus to each other in the blood serum and particularly the state of ionization of these elements
(iv) the influence of the parathyroids in maintaining the constancy of calcium in the blood
(v) the effect of ultra violet light whether artificial or in sun light
(vi) the influence of protein and fat in the food
(vii) the influence of the alkali reserve of the body
(viii) the effect of exercise

This long list has not exhausted the possibilities

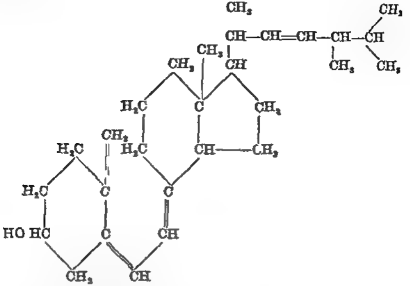
Now rickets may occur at all ages Though once strenuously denied, it is undoubted that fœtal rickets occurs, even in Europe though first described in China[1] Rickets usually occurs between the ages of 4 months and 18 months and spontaneous cure is frequent But rickets may be delayed till the third and fourth year of life Renal rickets which was once denied inclusion under the term rickets though the bone picture is identical has now been shown to be true rickets induced by disease of the kidney Graham and Oakley[2] cured the renal rickets in a boy of sixteen by treatment with alkali to increase the alkali reserve and with doses of 3000 to 6000 I U of vitamin D with exhibition of calcium lactate to increase the calcium intake Finally the disease osteomalacia is really adult rickets

Osteomalacia and osteoporosis must be distinguished Osteomalacia is a softening of the bones due to lack of vitamin D among other factors such as starvation and lack of mineral elements in the diet and its characteristic is the presence of osteoid material the organic part of bone without the inorganic Osteoporosis consists essentially of a diminution of calcium phosphate and carbonate in the trabeculæ of the bones Post-mortem no osteoid material is found[3]

Rickets is usually a disease of slum life and poverty, but not necessarily so It *appears much more frequently in* bottle fed babies than in breast fed though it is not absent in the latter This is so in spite of the fact that human milk contains much less calcium and phosphorus than cow s milk A diet overloaded with

[1] Maxwell (1930) *Lancet* 1, 454 and *Proc Roy Soc Med* 33 639
[2] Graham and Oakley (1938) *Arch Dis Childh* N S 1, 1
[3] Burrows and Graham (1945) *Quart J Med* 38 147

amounts It was called calciferol and was thought to be "the" vitamin D[1] Its formula is almost certainly



and it is 400,000 times as active in curing rickets as cod liver oil But it is by no means the only substance produced from sterol which cures rickets and it is probably not the substance in cod liver oil which cures rickets Thus it cures the rickets that occurs in rats but not the rickets from which chickens suffer which, however is easily cured by cod liver oil There may be six or eight forms of vitamin D, some natural some artificial The artificial vitamin calciferol is often called D_2 and the vitamin of cod liver oil D_3

In dietetics it does not matter much what the actual formulæ of the various substances are what we are concerned with is what they do in the body, how much of them and how long we should take them and in what foods we can find them

The problem of rickets was by no means solved by the discovery that the calcification of bones and teeth is controlled by vitamin D Because of the numbers of factors involved in ossification this is not astonishing If mathematicians cannot solve the problem of the gravitational effects of three bodies one on another it is not difficult to see that the much more complicated interrelation of the factors conducing to rickets demands time patience and much experiment to unravel The variables are manifold

(1) the vitamin D in the diet including the form in which it is presented whether as D_2 D_3 and possibly in other forms

[1] ASKEW BOURDILLON BRUCE JENKINS and WEBSTER (1930) *Proc Roy Soc B* 107, 76

Experimental results upon animals agree with clinical observations as regards cereals cod liver oil sunlight, ultra violet light, acidity of the gut high calcium low phosphorus in the serum phosphatase of the serum and the efficacy of vitamin D It has added that vitamin D_2 (calciferol) while useful for man and rat is useless for chicken [1] that metals such as beryllium [2] which form insoluble phosphates produce rickets the relation of calcium to phosphorus in the diet is important for both high calcium low phosphorus and low calcium high phosphorus diets conduce to rickets in the rat and when that ratio is 4 1 or 1 4 the animal needs increased doses of vitamin D to ward off rickets [3] Finally experimental work on puppies has explained the cereal effect on rickets [4] As will be indicated in the section on the milling of cereals (pp 308–17) the phytates render some of the calcium of the diet insoluble and so produce a low available calcium high phosphate chyme

The *causa causans* of rickets is a lowered intake of vitamin D or a lowered manufacture of that vitamin by the action of sunlight or rather by the ultra violet light the sunlight contains How it brings about the action is still a moot point

Here we meet a discrepancy between the views of clinicians and the experimentalists The clinician because of the fact that the calcium of the blood may be normal in rickets while it is the phosphorus which is lowered look upon human rickets as high calcium low phosphorus rickets The experimentalists particularly those working upon puppies look upon rickets as due to a low calcium high phosphorus diet in the absence of sufficient vitamin D or ultra-violet light Nutritional surveys support this view, for while poverty restricts the calcium intake it rarely reduces the phosphorus intake to a dangerous level [5] All agree that lack of vitamin D—or of sunlight or ultra violet light—is the all important factor in correcting the disturbed calcium or phosphorus metabolism How does it act ?

First of all its effect is catalytic When as little as 0 025γ can show its effect in a rat weighing 400 000 000 times as much its effect

[1] MÜSSEHL and ACKERSON (1930) Quoted by MCCOLLUM ORENT KEILES and DAY, *op cit* 340

[2] JONES (1938) *Am J Physiol* 124, 230

[3] MCCOLLUM ORENT KEILES and DAY (1939) *The Newer Knowledge of Nutrition* 173 *et seq*

[4] HARRISON and MELLANBY (1939) *Biochem Journ* 33, 1660 BRUCE and CALLOW (1934) *Biochem Journ* 28 517

[5] MCCANCE and WIDDOWSON (1938) *Journ Hygiene* 38 596 WIDDOWSON (1945) personal communication

cereals conduces to rickets [1] Cod liver oil has been known to be a specific for nearly a century [2] Sunlight prevents or cures rickets and this is due to its ultra violet light [3] Rickets is a "disease of darkness" whether the darkness be due to Purdah as in India, to smoky cities, or to northerly climates (In Glasgow smoke and deficient ultra violet light in the northerly sunshine are combined) Artificial ultra violet light is efficacious in curing rickets [4] Rapid rate of growth produces worse rickets than slow [5] Fats are useful and not only because of their content of vitamin D, though a diet very rich in fat may induce rickets [6] Cœliac disease, because of the patient's difficulty in absorbing fats and their contained vitamin D, is almost invariably accompanied by rickets Children with rickets often show an acidosis [7] Acidity of the small intestine antagonizes rickets Vitamin D prevents or cures rickets D_3 being more useful than D_2 [8] One large dose, say 100,000 I U given parentally, is as valuable as small daily doses by mouth [9] Idiopathic tetany in children is always accompanied by rickets, though rickets is by no means always accompanied by tetany [10] The serum of rickety children may have a normal calcium value (8–10 milligramme per 100 c c) whereas the phosphorus is always below the normal [11] There is often parathyroid hypertrophy in rickets,[12] and generally speaking the parathyroids are enlarged in northerly climes The blood phosphatase is increased in rickets [13] While vitamin D cures rickets parathormone makes it worse [14]

[1] TROUSSEAU (1865), *Clinique Medical del Hôtel Dieu de Paris* Second edition Quoted by BICKNELL and PRESCOTT (1942) *The Vitamins in Medicine* 452

[2] TROUSSEAU *Op cit*

[3] HUNTLY (1889) and PALM (1890) quoted by HOWLAND (1923) *Medicine* 2, 349 CHICK *et al* (1923) *Studies of Rickets in Vienna*, (1919–1922) *Med Res Counc Rep* 77

[4] HULDSCHINSKY (1919) *Deut med Woch* 45, 712

[5] BICKNELL and PRESCOTT (1942) *op cit* See also MELLANBY (1921) *Experimental Rickets Med Res Counc Spec Rep* 61, 33

[6] BOOTH HENRY and KON (1942) *Biochem Journ* 36, 445

[7] HODGSON (1921) *Lancet* 2, 945

[8] MAY, WYGANT *et al* (1939) *Arch Pæd*, 56, 426 Quoted by BICKNELL and PRESCOTT, *op cit*

[9] KRESTIN (1945) *Brit Med Journ* 1, 78

[10] HOWLAND (1923), *Medicine* 2, 349

[11] HOWLAND (1923) *op cit*

[12] PAL (1937) *Ind Med Gaz* quoted by BICKNELL and PRESCOTT *op cit*

[13] MORRIS (1937) *Lancet* 1, 87

[14] BICKNELL and PRESCOTT *op cit*

off into osteomalacia which is really adult rickets At the least—for osteomalacia is more frequent with women—extra vitamin D should be taken by women as long as child bearing continues

Calcium deposits can be organized up to old age and presumably in their organization vitamin D is needed, and moreover vitamin D[1] aids in averting caries and there is no age at which caries does not attack the teeth Consequently there is every reason for including vitamin D in the diet at any age, and for want of a better figure we may take the 500 I U necessary for children as the dose for an adult Doubtless it will take years for the shortage of vitamin D to which every adult in Great Britain has been subjected during the War to show its effects But there is no reason for saying that the adult needs none We have the experience of Vienna after the first World War when osteomalacia was of common occurrence as a warning against complacency of that kind

It has long been known that the skin condition lupus vulgaris can be greatly improved by means of the Finsen lamp This produces ultra violet rays and will therefore aid in the formation of calciferol in the skin It has now been shown that large doses of calciferol by mouth causes after an initial deterioration great improvement and healing of the skin lesions The doses given are 150 000 I U daily which with care do not cause any ill effects

There are extraordinarily few foods which are sources of vitamin D apart from fish liver oils There are the fat fish and the body oils of the eel herring and sardine have 4700 10 000 and 6000 I U per 100 grammes respectively,[2] and counting the oil as about 10 per cent of the flesh we get 470 1000 and 800 I U per serving of these fish Fresh herrings caught off the shores of Great Britain in 1941–42 contained from 84–479 I U per oz in the flesh or approximately 300–1170 I U per 100 grammes Canned herrings have about $\frac{1}{4}$ of this amount[3] Canned salmon contains from 200 to 800 I U per 100 grammes (about $3\frac{1}{2}$ oz) the red salmon having the highest value

Milk has from 0 to 10 units per 100 c c of vitamin D or 0 to 57 units per pint[4] (The higher figure is for summer milk) Winter butter has approximately none while the summer figure may be as much as 113 per oz The average figure is 34 per oz New Zealand butter may have nearly 90 per oz Eggs may yield 22–75

[1] MAY MELLANBY (1944) *Brit Med Journ* 1 837

[2] FIXSEN and ROSCOE (1937–8) *Nut Abs and Rev* 7, 823

[3] BACHARACH CRUICKSHANK HENRY KON LOVERN MOORE and MORTON (1942) *Brit Med Journ* 2, 691

[4] Cows fed on cacao shells secrete a milk with a higher vitamin D content KNAPP and COWARD (1935) *Biochem Journ* 29, 2728

must be catalytic But where does it act? In controlling the uptake of phosphorus from the gut, in influencing the alkali reserve, in retention of phosphorus in the body, in keeping the ionizable calcium of the blood constant via the parathyroid in holding the phosphorus in the blood and tissue fluids in a particular form in keeping the calcium phosphate calcium carbonate complex in the blood in a supersaturated state or directly, in governing the deposition of calcium phosphate in the osteoid tissue? We do not know as yet It will need much further research to elucidate the problem

All this may appear academic to the dietitian It is fairly clear that a low calcium intake compared with the phosphorus intake plus a low vitamin D intake conduce to rickets and the problem is to increase both Milk, cheese and fish are indicated as increasing the calcium intake without at the same time overincreasing the phosphorus intake, and the vitamin D by increasing the intake of the few foods which contain vitamin D or by use of fish liver oils as a prophylactic How much vitamin D is essential for the normal child and adult is still uncertain

As regards the cure of or protection from rickets, it is fairly certain that 500 I U per day form a satisfactory dose (The unit is the vitamin D activity of 1 milligramme of the standard solution of irradiated ergosterol and equals the activity 0 025γ of crystallized calciferol) This is the dose for a child How much is essential for an adult is not known A problem still unsolved is why so many children show no obvious signs of rickets though their daily intake of vitamin D must be well below the level of 500 I U Mild rickets occurs in many babies, but we should expect it to be much more obvious if this figure is near the minimum Idiosyncracies of absorption of calcium, phosphorus and vitamin D and utilization of these essential factors may be the explanation or varying exposure to sunlight Diarrhœa and dosage with liquid paraffin may impede absorption

Another problem is how long this intake of vitamin D should continue Almost certainly it should start before birth *There is* evidence from China, from America, and Scandinavia that the bones of the new born are better calcified if the mother has had adequate doses of calcium and vitamin D during pregnancy *The formation* of bones and teeth starts before birth and continues till the last teeth are erupted, which may be not till 18 to 21 It is true that the usual age for rickets is 6 months to 18 months but it *will be remembered* from the above that there are such diseases as renal rickets fœtal rickets [1] and delayed rickets and that delayed rickets shades

[1] MAXWELL 1930 *Lancet* 1 454 and (1930) *Proc Roy Soc Med* 23 639

a sufficiency But if his powers of absorption of fat are lowered or his intestinal flora depressed by a long course of sulphonamides he may suffer from a deficit Babies when born have a sterile gut and it takes two or three days to establish therein a good bacterial flora If then the mother's diet has been deficient in K_1 or her absorption of K_2 from her colon been poor, the baby is born with a lowered prothrombin titre of its blood Hæmorrhagic disease of the newborn is often attributed to lack of vitamin K and the Scandinavian school of obstetricians and pædiatricians use vitamin K as a prophylactic[1] American data are not so encouraging

In dietetics vitamin K is not important because a diet satisfactory for the earlier discovered vitamins particularly A and C will most probably contain K

Vitamin P

In the section on vitamin C above, ascorbic acid and that vitamin have been equated If however vitamin C is defined as that vitamin which wards off *all* the symptoms of scurvy then vitamin C activity includes more than the activity of ascorbic acid One of the symptoms of scurvy is the formation of petechiæ small extravasations of blood under the skin These can be produced artificially by suction over a small area of skin and the negative pressure under which petechiæ appear measured In scurvy it takes a much smaller tension (or negative pressure) to produce petechiæ—i e the resistance of the walls of capillaries to tension from without and presumably pressure from within, is lowered. Now according to the majority of workers who have investigated it this lowered capillary resistance is not due to lack of ascorbic acid in the diet but of another vitamin[2] Szent Gyorgyi, who first called attention to this considered that it was the capillary permeability which had been altered not its fragility and so called the vitamin vitamin *P* He first related this vitamin activity to hesperidin a flavone occurring in orange peel and pulp but later he considered that the active substance was eriodictiol which is not easily separated from the hesperidin Later workers have prepared a water soluble substance which has 100 times the activity of recrystallized hesperidin and is active at the microgramme level rather than the milligramme[3]

Vitamin P occurs alongside of ascorbic acid in many fruits and

[1] LEHMANN (1944) *Lancet* 1 493 506 and 2 737
[2] Rats can suffer from the absence of this vitamin but can manufacture ascorbic acid
[3] BACHARACH and COATES (1942) *Analyst* 67 313

Other Vitamins

As research continues, it is highly probable that more vitamins will be discovered and that later these will be shown to be important for man Many have been discovered or postulated for this or that animal and it may be that one or another will prove to be indispensable in human nutrition One such vitamin—Vitamin K—known to be important in the feeding of chicks, sprang into a position of more than theoretical importance late in 1939 [1] It was shown by Dam that a number of infants with a syndrome of symptoms including jaundice, hæmorrhage and dropsy, had a reduced clotting power of the blood In chicks suffering from a lack of this vitamin the resulting diminished power of coagulation of the blood is due to a lack of prothrombin and feeding them with vitamin K restores to the animals their power of making prothrombin

Further, four adults were shown by Dam to be deficient in prothrombin as the result of a lack of this vitamin Three had scurvy and one pellagra, therefore their diet was highly deficient in ascorbic and nicotinic acids All had a low prothrombin level which became normal 24 hours after treatment with vitamin K Low prothrombin levels have been observed in patients suffering from obstructive jaundice sprue, biliary fistula and ulcerative colitis—diseases in which there is either a lack of bile salts in the alimentary tract or poor absorption

There are two naturally occurring substances which restore to the blood its lost power of clotting (i) vitamin K_1 or 2 methyl 3 phytyl 1 4 naphthoquinone and (ii) vitamin K_2 or 2 methyl 3 difarnesyl 1 4 naphthoquinone The first is found in green vegetables, e g cabbage spinach, green peas alfalfa or lucerne but not in fruits or cereals the second is manufactured by bacteria including those living in the gut

Both these naphthoquinones are soluble in fat and fat solvents but are insoluble in water Consequently the body has difficulty in absorbing them when there are no bile salts in the gut or in other cases (e g sprue) when the absorption of fat is deficient Medicinal paraffin oil impedes the absorption of vitamin K

Commercial 2 methyl 1 4 naphthoquinone is even more active than the natural vitamins and though mildly toxic is replacing them in therapy

It will be clear from the above that the normal person eating a mixed diet including green vegetables is never likely to suffer from a lack of vitamin K Even in the absence of these vegetables he can rely on the microbes in his large intestine to manufacture

[1] DAM (1939) *Lancet* 2 1157 and 1162

a sufficiency But if his powers of absorption of fat are lowered or his intestinal flora depressed by a long course of sulphonamides he may suffer from a deficit Babies when born have a sterile gut and it takes two or three days to establish therein a good bacterial flora If then the mother's diet has been deficient in K_1 or her absorption of K_2 from her colon been poor, the baby is born with a lowered prothrombin titre of its blood Hæmorrhagic disease of the newborn is often attributed to lack of vitamin K, and the Scandinavian school of obstetricians and pædiatricians use vitamin K as a prophylactic[1] American data are not so encouraging

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vegetables, but they are not present to the same extent[1] It is true that the water soluble extract having the greatest amount comes from black currants which have large amounts of ascorbic acid but plums and prunes which have practically no ascorbic acid are rich sources of P[2] Generally speaking, vitamin P is much more widely distributed than ascorbic acid but the range of values is not so great Even dried peas have some Moreover fruits, roots and salad plants, apt to be neglected because of their low content of ascorbic acid, have reasonable amounts of vitamin P For example we mention blackberries, cherries grapes, plums and prunes, also carrots and lettuce So that in practical dietetics it comes to this a diet containing a fair amount of fruits and vegetables will contain a satisfactory amount of vitamin P Rich sources of vitamin P include apples, blackberries, blackcurrants, cherries grapes, lemons, oranges, plums and prunes among fruits and cabbage, cauliflower, lettuce, parsnip and spinach among vegetables Tomatoes, too, are satisfactory[3] As far as figures are available it is seen that if ascorbic acid is provided by means of natural foods vitamin P will also have been provided

Meanwhile vitamin P concentrates have proved useful in treating purpura and various hæmorrhagic conditions of stomach, kidney and lungs

However important in science and medicine the vitamins discovered in the future may prove to be it is unlikely that such discovery will make much difference to the principles and practice of dietetics The more recently discovered vitamins were discovered only because the earlier vitamins had been isolated and purified and of course generally speaking, the more widely distributed and easily isolated vitamins were the first to be isolated and synthesized If the physician is treating deficiency diseases with vitamins he should use a blunderbus preparation of all the known vitamins for deficiencies are rarely single but multiple Now a mixed dietary containing dairy foods fruit and vegetables fish and whole cereals is a blunderbus diet It contains all the known vitamins and probably all the unknown vitamins as well, whereas a blunderbus vitamin concentrate may, and probably will, exclude the undiscovered ones

[1] BACHARACH and COATES (1943) *Journ Soc Chem Ind* 62, 85

[2] SCARBOROUGH (1941) *Proc Bioch Soc* July 18

[3] These statements are based upon work by SCARBOROUGH on man and on preliminary reports by Geoffrey Bourne which we have been privileged to see See also BACHARACH and COATES upon guinea pigs, *op cit* and SCARBOROUGH (1941) *Chem and Ind*, 60, 618

CHAPTER VI

PRACTICAL ASPECTS OF KNOWLEDGE OF CALORIES PROTEINS, MINERAL ELEMENTS AND VITAMINS

It is time to sum up the facts and evidence put forth in Chapters II to V and to show as briefly as possible how an optimal diet may be obtained To quote Sherman sound diet stands four square upon Calories proteins mineral" elements and vitamins Each group is important and each member of each group is important and in its absence the body sooner or later dies Perhaps the importance of water should be emphasized as well The body as has been said above lasts some 4 to 5 days only without water some 50–70 days without Calories and protein and much longer without most of the mineral elements and the vitamins

The average man and indeed the average dietitian, cannot carry around in the memory the mass of facts which have been adduced about the Caloric value the percentage composition the mineral element and the vitamin values of the multitudinous foods which appear even in a modest diet Nor is it at all necessary that such data should be memorized That way a sort of madness lies and an overweighting of some food or type of food dear to the heart of the particular dietitian (Years ago Langdon Brown said that the likes and dislikes of a physician could be gauged by what he allowed—or forbade—his dyspeptic patients to eat) Interest in this or that vitamin or mineral element often hides an interest in this or that food All that is necessary is to group the foods in the simple plan already laid out on p 17

It will be seen from the four preceding chapters that foods which are most important for Calories come mainly from the grocer and baker those for protein come from the dairyman the butcher and the fishmonger while those which supply the mineral elements and the vitamins come from the dairyman the green grocer and the fishmonger Sundry foods recur again and again on the lists

For example milk appears as a source of first class protein, of calcium and phosphorus of vitamins A and to a smaller extent of the vitamins riboflavine nicotinamide, ascorbic acid and in summer, D It is moderately useful in supplying Calories—as good as potatoes Cheese and other milk products also are valuable in similar ways—cheese and butter yield many Calories too Eggs add iron to the good qualities of milk but are a dear source of Calories Herrings and the fat fish generally are useful for protein, calcium, phosphorus, iodine, vitamins A and D riboflavine and nicotinic acid Nor are they to be despised as sources of Calories In fact the enquiring mind is driven to assume as fact the great importance of the dairy foods and fat fish in the diet Nor is he allowed to forget the market garden produce—the vegetables for vitamins A and C and for iron and possibly calcium, the summer fruit for vitamin C, most fruits for vitamin P and the imported citrus fruits also for vitamin C

Perhaps the matter may be displayed in tabular form

1 Foods for Calories		Dripping frying fats suet butter margarine bacon cheese flour bread cakes biscuits sugar dried fruits jam golden syrup treacle potatoes
2 Foods for Protein		Milk eggs meat fish cheese
3 *Foods for* Mineral Elements	Calcium	Cheese fat fish milk eggs
	Iron	Eggs green vegetables liver and cooked meat
	Iodine	Fish from the sea seaweeds
4 Foods for Vitamins	Vitamin A	The dairy foods green and yellow vegetables *liver and tomatoes*
	Thiamine	Yeast wheatgerm liver kidneys pork bacon and ham whole cereals whole meal and wheatmeal bread
	Riboflavine	Yeas wheatgerm liver skimmed milk powder cheese fish and milk
	Nicotinic acid	Yeast fish meat offal wheatgerm meat
	Ascorbic acid	Summer fruits citrus fruits green vegetables liver a few roots of the cabbage and *tomato tribes*
	Vitamin D	The fat fish and summer milk and butter

Now leaving on one side for the moment Calories and protein and turning to the mineral elements and the vitamins we can group them roughly as follows

(i) Dairy foods i e milk butter cream cheese and eggs (and 'war time' margarine)

(ii) Greengroceries, i.e. "greens," carrots, swede, turnip, radish, tomatoes, summer fruit, citrus fruits.
(iii) Sea produce, i.e. fish, particularly the fat fish, shell fish and seaweeds.
(iv) Whole cereals (but with these much dairy food and greens must be taken to outweigh the deleterious effect of the cereal phytates on the intake of calcium and iron).

In Great Britain the diet on the whole has been satisfactory in the past as regards Calories. Only the "submerged tenth"—far too large a proportion—have not had enough Calories. (In India, however, 30 per cent. fail to attain even sufficient Calories.) On the whole, too, the diet has been satisfactory as regards protein, though perhaps not for first class protein. It is in the dairy foods, the greengroceries, the sea produce and possibly in the whole cereals that the diet has been deficient. The reason is partly cost, partly defective transport, partly lack of education and partly poverty. Poverty does not directly explain the refusal to eat whole cereals and rice, except that poverty prevents people from buying milk and vegetables which are essential if whole cereals are taken to any large extent.[1]

These foods which we have listed (i) to (iv) above have received the name *protective foods*. The term originated with McCollum, who first applied it to milk and green leaves which protect rats from the deleterious effect of an exclusively cereal diet. Then in time it was extended to all foods which contain the necessary mineral elements and vitamins in any considerable amount, and the term has received the blessing of most dietitians.

It is easy to criticize it. It is unscientific and untrue. All food protects you against hunger and death in 50 days. Water protects you against death in four days. You can carry on for months without a reasonable supply of calcium, iron, iodine, vitamins A, C and D in your diet, as Marrack points out. Moreover, the term has given rise to the expression "protected food," meaning a food which has not had its vitamins destroyed by processing or cooking. Wholemeal is sometimes described as a "protected food." This is as reasonable as calling an army with machine guns and no heavy artillery, tanks or air force "protected." Probably the best usage of the term "protective foods" is in the sense of the foods which protect the layman from making a dietetic fool of himself. The term is a useful one though unscientific and

[1] Sir Edward Mellanby has maintained that it was a wise instinct which kept the poor off wholemeal bread.

it has a great value for propaganda purposes It is because the diet of Great Britain, and indeed most other countries, needs improvement by the addition of just those foods that the term "protective foods" is retained It should encourage politicians and agriculturists and the city folk to the spending of thought time, energy and money on the correct feeding of the nation The supplies of dairy foods, market-garden foods and fish should be at least doubled, and with the climate, soil and position of the British Isles that should easily be possible It is a policy which would make for the health of the townsman and the economic health of the nation The market is here at the door and the problem of getting the goods fresh to the table is one of co operation, transport, refrigeration on the way and in the home—problems by no means insoluble

Given a supply of fresh "protective" foods, of groceries, bread, confectionery, and meat, how should an optimal diet be constructed? There are two ways We can start right from the beginning, making away with all the schedules of menus we have had in the past, or we can take those schedules and by criticizing them in the light of knowledge of the "protective" foods amend and bring them up to modern dietary standards Probably the latter will be the more popular and certainly more British way of solving the problem Either plan followed wisely will produce much the same result One produces a safe diet, the other makes the diet safe

The radical plan, i e going to the root of things and altering thence upwards consists in (i) getting first of all a sufficiency of the "protective" foods or, if you prefer it, the foods rich in mineral elements and vitamins (ii) second in supplying foods with first class protein in them and (iii) making up Calorie needs from the foods which are mainly used to supply Calories

Let us take an example, at the moment of writing impossible of fulfilment because of post war conditions, but easily possible with a planned agricultural and food policy in the near future

Protective foods Dairy foods Milk, 1 pint Cheese, 1 oz
Butter, 1½ oz Egg 1 per day
Greengroceries 4 oz tomatoes and 3½ oz
green vegetables or carrots per day
Fish 1 lb of herrings per week
Wheatmeal bread 8 oz per day

These work out as follows taking average figures from the tables

	Calcium mg	Iron mg	Vit A I U	Thiamine γ or μg	Riboflavine γ or μg	Nicotinic Acid mg	Ascorbic Acid mg	Vit D I U
Milk : 1 pint	680	0 0	400	260	965	0 6	6	28
Cheese : 1 oz	230	0 2	369	9	47	—	0	—
Butter 1¼ oz	12	0 0	1704	0	2	—	0	41
Egg 1	30	1 5	500	75	200	—	0	22
Tomatoes 4 oz	12	0 4	964	56	57	0 6	24	—
Greens 4 oz	46	0 7	210	50	45	0 3	15	—
Herrings 2¾ oz	41	0 7	64	4	65	1 9	0	192
Bread [illegible] oz	128	4 0	0	421	68	2 0	0	—
Total	1179	7 5	4211	878	1449	5 4	45	283

And, in addition to the above, the diet so far as prescribed has nearly 60 grammes protein of which 38 is animal protein 77 grammes fat and 147 grammes carbohydrate and yields over 1500 Calories i e on the score of protein and Calories it is sufficient for *some* women [1] It is already safe as regards calcium vitamin A and ascorbic acid but is still a bit doubtful in iron thiamine, riboflavine and nicotinic acid and possibly in vitamin D

Very few people would be satisfied with the animal protein of such a diet and would want to add say 2 oz bacon and at least 2 oz meat a day If these are added the diet has 73 [illegible] grammes protein 1854 Calories and 10 milligrammes iron, the thiamine has reached 1 2 milligramme, the riboflavine 1 [illegible] milligramme and the nicotinic acid 13 milligrammes So that by now although the figures for the iron and vitamins have not reached the levels recommended by the National Research Council of the U S A the diet is deficient practically only in Calories There is a leeway of 1200 to make up if we are aiming at 3000 and this can be done in any way which is convenient agreeable or economic In peace-time probably more fats would be used In war time more bread or flour Potatoes up to 8 oz a day might be eaten Jams golden syrup honey and treacle might be used as spreads or in cakes and puddings Sugar too would add to the Calories though to nothing else The middle classes would certainly take more meat and add fruits and salads There should be no difficulty in making the diet completely satisfactory by a wise choice among the foods chosen to make up the deficit in Calories

The other line of approach to the solution of obtaining a satis

[1] WIDDOWSON and MCCANCE (1936) *Journ Hygiene* 36, 294

factory diet is to take the normal diet to which the person to be fed is accustomed and to amend it by including the foods given above under the heading of protective foods

For example, the following is a day's menus from a boarding school

Breakfast	Porridge bacon half a fried tomato bread and butter marmalade Tea
Mid morning snack	½ pt milk
Dinner	Cold roast beef mashed potatoes pickles rice pudding bread
Tea	Brown and white bread and butter small cake or scone Tea
Supper	Bread and butter baked beans on toast, and a biscuit Water

We can be fairly certain that this diet will be adequate as regards Calories and first class protein especially if as is fortunately common in peace time in boarding schools second helpings of meat are allowed and bread butter and jam are *ad lib* But when we scrutinize the diet for the protective foods we begin to wonder if it is adequate

The dairy foods are represented by milk and butter only The boys may be getting one pint of milk a day but it is doubtful It would be much sounder to supply milk to drink at breakfast and supper or if the pupils think milk to be babyish milk with a "dash of coffee" Cheese is completely neglected on this day, and as a matter of fact, was neglected on nearly every other day of the week

The market-garden foods and special fruits are also absent except for the half of a fried tomato To amend this diet it would be well to replace the pickles of dinner with a salad of tomatoes water cress or mustard and cress, or if by carrots—which go quite well with cold roast beef—then later in the day an orange or lemonade made with fresh lemons should be given or some fresh or canned summer fruits [1]

The remaining meals are practically devoid of protective foods except that some brown bread is provided but there is no adequate source of vitamin D anywhere in this day's menu Nor did much appear anywhere else in the week under consideration Instead

[1] It is amazing how infrequently fruit appears in the diet of people in this country Of course fruit is dear and scarce But it is conceivable that school gardens at any rate could grow bush fruits The dietitian of an institution should have the chief say in what should be produced in the garden

of the baked beans herrings, kippers bloaters or soft roes on toast might well appear, or a white fish dish with a sauce fortified with vitamin D in cod liver oil (see p 182)

Most middle class diets which are adequate as regards Calories and first class proteins can easily be made satisfactory in all directions by the replacement of some of the foods served by those in the four classes of protective foods listed above All classes must be well represented This method of obtaining a satisfactory diet involves but the simplest knowledge of dietetics and moreover avoids the one sided fanaticism which insists on, say potatoes boiled in their skins, the use of the water vegetables are boiled in, or the exclusive use of unmilled cereals, which, though they may solve the problem of sound feeding in one direction, completely omit to solve it in others

CHAPTER VII

THE PROCESSING AND STORAGE OF FOODS

One of man's greatest difficulties in preserving himself alive on this planet has been the alternation of glut and famine due in early history to the flux of the seasons and the uncertainty of the weather, and now due in addition, to the economic and political systems under which he subsists Man's endeavour has been to use the surplus of the glut to provide food in time of famine The storage of food is the beginning of capitalism, and the first large scale storage of food recorded in Egypt under the foresight of Joseph, a Jew the beginning of state capitalism Man wants to make food keep

Now there are some foods which, with a little care, can be made to keep for years These are the cereals, and it is not astonishing that civilization has grown up round the centres of cereal production for this and for other reasons to be developed later in this book Cereals stored in the dry and protected from the inroads of insects and rodents will keep almost indefinitely The plant has used 'dehydration to preserve its means of propagation from one season to the next Probably therefore, cereals were the first things to be stored from one year to the next Other seeds, such as the pulses, also can be kept almost indefinitely

Protein containing foods especially the prized meat, poultry and fish will not keep They form an excellent nutrient medium for the growth of microbes mainly the putrefying ones A dead animal soon rots and develops unpleasant odours and unless one is brought up to eat decomposed meat game eggs and fish, it becomes unfit for consumption "[1] Such decomposition is aided by the blow fly the maggots of which render meat protein soluble Putrefaction depends upon the presence of digestible protein and moisture If the moisture content is reduced considerably these protein foods can be kept against a rainy day . Meat and fish

[1] We eat game and cheese in a state of putrefaction the Eskimos eat decomposed meat the Chinese eat pidang—i e duck s eggs which have developed the odour of decay No harm results

have been dried in the past by native races and are still being dried to make them keep Pemmican of the Red Indians and Charque of South America and the dried fish of the Eskimo of the Mackenzie River delta are examples And to day this process of dehydration (really, of course drying) is being used on a large scale to feed British and American armies overseas The one naturally occurring high protein food (pulse) keeps very well because of its low content of water

The moisture of fruits and vegetables allows moulds to ruin their palatability For many years this has been obviated by drying the fruit and there is an extensive trade in dried grapes (muscatels raisins sultanas and currants) dried apples and pears dried figs dried apricots and peaches and plums both in war time and in peace Some of these owe their keeping qualities in part to their high content of sugar Dried vegetables have been used in every war within the last 100 years but with ill results because of the destruction of the vitamin C in the methods of drying used In the war of 1939–45 the difficulties of drying vegetables have been overcome their ascorbic acid value has been preserved and they can be reduced in weight to one twentieth or less and be transported to the desert or the Arctic Circle, and when rehydrated and cooked are as good as or possibly better than vegetables from the home market After the war it is likely that the trade in dried vegetables will expand They offer too many advantages to the restaurateur to be neglected

Dehydration of fish and meat has made such strides that it is likely that much of the fish cakes and mince we eat in restaurants in the future will be made from dehydrated foods The problem of dehydrating joints and large pieces of meat has not been solved if it ever will be so that no one need suspect, as yet that a chop or a steak, or a cut from the joint has come from a dehydrated source

Most of us have become familiar with dried milk and dried eggs during the war 1939–45, but dried milk is said to have been made by the Tartars in the thirteenth century,[1] and it has been used in infant feeding since 1906[2] Dried eggs though dating from the first World War, have become a standby in the war of 1939–45 and though their taste and flavour are not equal to that of "shell" eggs they are an exceedingly welcome addition to the war time commissariat They represent an enormous saving in carriage

If and when China becomes a settled and peaceful and indus

[1] Appleton (1942) *Proc Nut Soc* 1, 114
[2] Coutts (1918) *Loc Gov Board Rep* 116, 1

trialized country it will be a chief source of dried eggs During the second World War the eggs were produced and dried in Canada and the United States Before this war large quantities of eggs, shelled and frozen, were imported from China into this country for use in the confectionery and margarine trades There was considerable outcry from the poultry industry but it seemed hardly justifiable

Drying then is a means of making foods keep though not indefinitely The housewife uses the fat when she turns the cold roast joint over on its dish every twenty four hours If left moist side down the putrefactive microbes can soon render the moisture (i e gravy) putrid and foul smelling But if the moist side in contact with the dish is turned uppermost it dries and the microbes cannot thrive

One type of drying is to produce such a concentration of sugar in the food to be preserved that microbes cannot grow In jam making the final sugar content is raised to over 60 per cent., in which strength of solution microbes will not grow The honey bee uses a similar technique, though it is said also to add a little formic acid as a preservative In the making of glace and crystallized fruit the cell juices are replaced by stronger and stronger solutions of sugar until a strength is reached in which no microbe can grow Sweetened condensed milk owes its keeping power partly to the condensation, partly to the concentration of sugar and partly to the bacteriological cleanliness used in its preparation

The ***salting*** and ***smoking*** of meat, particularly pork, has been practised for more than 500 years The meat keeps because the outside layers have such a high concentration of salt that invasion from outside is impossible The microbes cannot live in the strength of salt solution found in the outer layers of the meat The inside of the meat starts sterile, is protected in the early stages of pickling by its acidity and in the later stages by the salt in the outer layers Potassium nitrate—saltpetre—also used in curing bacon and ham—is an antiseptic Further, smoking when used partly owes its effect to antiseptics in the smoke and partly to the effect of still further drying the meat (The salt will have extracted some water already) It should be realized that the inside of a ham can easily undergo putrefactive changes if cut and exposed to the air There is not enough salt there to plasmolyse microbes It normally remains sound because protected by layers of concentrated salt on the outside though infection may travel along the bone or along the big blood vessels near the bone

Micro-organisms are the main though not the only, cause of spoiling of foods but some strains of the acid producing microbes

can be used to preserve food or at least to stave off putrefaction By souring milk particularly if alcohol is formed at the same time the milk can be made to last longer than normal Sauer kraut is cabbage preserved by means of acid producing bacteria and is popular as an edible both in Germany and in the German settled parts of the United States Silage is cattle fodder treated in a similar way Green Indian corn stalks and other fodder plants can be preserved throughout the winter as fodder for cattle and retain much more of the nutritive value than if first dried

Another way of making food keep is to *fractionate* it i e keep one fraction and throw away the rest Butter is the fat of milk but the caseinogen and the lactose of the milk from which the butter originated must either be used at once or dried It was, until recently thrown away or at the best used as pig food The Household milk of the war of 1939–45 is the skimmed milk arising from the manufacture of butter on the North American continent Cheese is really fractionated milk. The fat and the caseinogen plus the calcium of the milk are preserved and the lactose and lactalbumin largely wasted (Dried whey, the residue of the milk after the casein has been produced is a valuable food) Fractionating cereals also improves their keeping qualities but for a different reason The oil of the cereal germ readily goes rancid in air and the mixed proteins of wholemeal support insect life better than those of white flour White flour does not readily develop an off flavour whereas wholemeal does Whole wheat keeps better than wholemeal and white flour nearly as well as whole wheat This fact probably explains the determined opposition of the milling and baking industry to the production of war time flour and bread

Antiseptics i e substances inimical to microbic life have been in the past and are still being used to preserve food Hops are added to the wort in beer making because they contain an antiseptic The beer keeps better The commonest artificial antiseptics are benzoic acid and benzoates boric acid and sulphites Benzoic acid is used in the fruit juice industry boric acid in cream and sulphite in sausages and fresh fruit In this country it is no longer legal to use benzoates and boric acid but sulphites are permitted in sausages Before the war of 1939–45 the jam makers of this country imported much fruit especially black currants from the Continent preserved with sulphite and the Camden solution used in bottling fruit is a source of sulphur dioxide The function of the antiseptic is to poison life and there is always the possibility that it may upset human life, so the tendency is to move

away from antisepsis towards asepsis in the food industry as in surgery

If we can put up a susceptible food in a container free from microbes it will remain unchanged almost indefinitely This is the principle behind the *canning and bottling* industry which has grown to such an immense size during this century On the commercial scale it is quite impossible to prevent some microbes (bacteria or fungi) from coming into contact with the meat, fish, fruit or vegetables to be preserved before they go into the container—in fact this would be possible for meat, only in the most up to date operating theatre—but those which obtain entrance are killed by boiling or heating under pressure, and the vessel sealed before any more live microbes can make their entrance With fruits and vegetables it is not necessary to raise the temperature much above the boiling point of water but with fish and meat the temperature surrounding the container has to be raised to 125° C partly to allow the heat to penetrate to the centre and partly because the hydrogen ion concentration of meat and processed fish is favourable to the growth of putrefactive microbes while that of fruits and vegetables is not More care to destroy all microbes is necessary with meat than with fruit and vegetables

It should be mentioned that the greatest care has to be taken of fruit, vegetables, meat and fish before they are canned Nothing but the best and cleanest are good enough, and the time between harvesting or slaughter and inclusion in a container has to be the shortest possible Fruits and vegetables are canned within 24 hours of picking or pulling and often preserve more of their vitamin C than similar goods sold " fresh " on the open market Cleanliness is at a premium in a cannery for the fewer microbes which get into the cans before sterilizing the better That they do get in at times is shown by the " blown " cans, and the occasional occurrence of food poisoning due to canned goods In spite of these occurrences which are rare, the practice of canning foods has come to stay It is very valuable in taking advantage of a glut in transporting foods from one part of the world where they are cheaply and easily produced to another where they are produced with difficulty, if at all and in increasing the range of food stuffs available

There is still a strong prejudice against canned goods though it has but little basis in dietetics There is little if any damage done to the nutritive values of the protein, fat and carbohydrate, vitamin B, it is true, is probably destroyed and there is loss of vitamin C None the less, it is true that canned fruits and vegetables often contain more vitamin C than similar fruits and vegetables bought in the open market and cooked in the home *The objections*

to canning are mainly æsthetic and moral Often canning changes the flavour of goods for the worse though there are people who prefer canned pineapples and grapefruit to fresh, and some, canned ox tongue to fresh and connoisseurs maintain that the longer sardines remain in their cans the better Generally speaking the flavour of canned goods does not approach that of fresh foods Moreover, there is the indictment on moral grounds The use of canned goods is held to be lazy and jeers are made about the mountains of empty cans to be found near the back doors of the working classes As a matter of fact the big hotels are the greatest users of canned goods—they are so convenient and standardized in appearance It is much easier to warm and open a can of nicely graded and dyed green peas than to shell and cook the product of a city market Meanwhile it must be admitted that it is *dietetically advantageous to be able in winter to open cans* of black currants loganberries spinach and new potatoes in this country, or in the northern parts of the United States or Canada where the snow is on the ground for 5 months of the year and to have summer fruits and vegetables available in winter and early spring

Fruit juices and for that matter meat juices can be rendered sterile by filtration through Chamberland filters, i e unglazed porous pottery filters with holes so minute that they hold back the microbes This method is used on an increasing scale in the United States *but it is not suitable for all fruit juices for it holds* up at the same time some of the flavour

Partial heat sterilization or *pasteurization*, is used with milk and fruit juices Pasteurization consists in raising the temperature of the fluid to be pasteurized to a height varying for each food and keeping it there for a definite time The length of time varies with the temperature Thus milk has to be held at 145° F no less than 30 minutes—the so called holder process—whereas if it is raised to 162° F the time necessary falls to as little as 15 seconds When the time is so brief the process is termed flash pasteurization Until the war of 1939–45 the holder process was the one favoured in this country but flash pasteurization despite its difficulty in control has been permitted since 1941

The function of pasteurization is (i) to kill pathogenic germs such as those of tuberculosis undulant fever typhoid etc and (ii) to destroy most of the lactic acid producing microbes This enables the milk to keep much longer—properly pasteurized milk made under laboratory conditions will keep a month and commercially pasteurized milk as put up by a well known dairy in Dorset will last five or six days in summer before going sour Such milk

is not sterilized—there may be heat resisting spores in it, which will later germinate and invariably a few lactic acid producers escape destruction Pasteurization kills the more abundant and non spore forming microbes and so delays souring [1]

Cold delays microbic activity milk which would keep two or three days in cold weather will last hardly a day in warm, frozen meat will keep indefinitely There are stories of hunters in the Arctic Circle coming across frozen mammoths which must have gone into cold storage æons ago, the meat of which, when thawed out, was perfectly edible Low temperature does not destroy microbes, it merely puts them in a state of suspended animation, and in the household refrigerator they continue to live but reproduce themselves much more slowly For example, as quoted in the *Farmers' Bulletin No 1705 of the U S Department of Agriculture* (1933), a high quality raw milk which started with 31,000 microbes per cubic centimetre had increased these by four times only after 24 hours in a cool chamber at 50° F, whereas the same milk left for 1½ hours at 75° F before its 24 hours in the cooler had 10¾ times as many microbes *If the refrigerator had been working at 32° F* the increase would have been much less—probably the numbers would not have doubled in 24 hours [2]

Cold storage then has been used in ever increasing degree in the last 50 years One of the difficulties encountered in preparing for feeding the people of Great Britain during the German air raids was that the cold storage plants were naturally enough in our dock areas and so exposed to attack Beef is imported from the Argentine chilled i e not actually frozen, whereas mutton can be imported from New Zealand to this country frozen Frozen mutton when thawed retains its structure practically unchanged but beef if frozen, loses a large amount of "drip," i e muscle cell fluids or meat juice when thawed The length of time which chilling delays putrefactive decomposition by microbes in beef is not much more than that taken between the Argentine and our western ports and that sets a limit to the distance from which beef was imported till gas storage was discovered

Fish can be frozen at much lower temperatures than meat with advantage and after the war of 1939-45 it is probable that factory

[1] The advantage to the producer the distributor and the consumer of the delaying of the souring of milk in a highly urbanized civilization is obvious This leaves out of account its advantage to health, for which see under milk

[2] Davis (1944) *Food Manufacture* 19, 423 states that laboratory pasteurized milk will keep 32 days at 45° F and up to 63 days at 34° F

ships supplied with machinery for rapid and low temperature freezing will accompany the fishing fleets Such frozen fish if later stored at 10 degrees below freezing may remain good and untainted for eight months and acceptable" after four years!

The trouble has always been in the fish supply in this country, that much of the fish when landed was off," and when transported inland was by no means fresh Refrigeration both on fishing fleets and on the railways could render the supply of fresh fish in the remotest parts of Great Britain—no part is more than 70 miles from the sea—an easy matter The advantage of such a supply is obvious from the sections above on protein and nicotinic acid

Gas Storage Many foods e g fruits and vegetables are living entities and carry on a slow metabolism during storage Others have substances in a state of complicated equilibrium which is dynamic and not static That is the equilibrium slowly moves, sometimes towards improvement of flavour (wines and cheeses are examples) and sometimes in the opposite direction (e g meat) Sometimes the foods contain oxidizable substances usually fats and fatty acids and the oxidation of these produces 'off' flavours It has been discovered that carbon dioxide in varying percentages will slow still further metabolism in fruits, i e will inhibit ripening processes, will check the development of unpleasant flavours and stop oxidation Nitrogen could be used for the latter purpose but because carbon dioxide can be supplied in solid form cheaply it is the more convenient 'gas" in which to store food Gas storage is still in its infancy but it has already solved the problem of carrying meat, particularly beef from the Antipodes to Europe

Eggs have presented peculiar problems in cold storage The egg within its shell is by no means completely sterile and the washing of eggs seems to remove some barrier against invasion by microbes from outside Eggs in cold storage develop a storage flavour and sometimes serve as a medium for 'musty odour" producing microbes This ruins them as food Moreover, the firm white of the egg becomes runny and so enables it to be distinguished from a new laid egg A fried cold storage egg looks nowhere near as appetising as a fried new laid egg Many of these troubles have been obviated by gas storage in combination with cold storage The gas is usually carbon dioxide though it may be nitrogen Percentages ranging from [illegible] to 100 can be used according to the food to be preserved Higher concentrations are best for eggs but lower percentages are used with meat and fruit (see below)

Gas storage has aided in the preservation in transport of foreign fruits to this country Quite a low percentage of carbon dioxide

is all that is necessary The fruit is picked unripe and ripens on its journey to this country and in storage The rate of ripening has to be modified according to the distance to be travelled and the time when the fruit is put upon the market Cold delays ripening But the fruit is a living breathing organism and some of the products of metabolism if not removed, speed the ripening Carbon dioxide delays it So in ideal conditions there should be a circulation of air around the fruit and its carbon dioxide content is best kept at 5 per cent Gas storage of apples has proved of great value and it may in future be possible to pick bananas much more nearly ripe and so preserve some of the qualities of a banana picked ripe from the tree

Gas storage, too has solved the problem of preventing the development of "off flavours in dehydrated foods particularly those which have to pass through, or be stored in tropical climates Originally with dried milk coming from New Zealand a vacuum was used to prevent the development of 'off" flavours which probably are due to the fats becoming rancid Dehydrated meat, fish and eggs retain their qualities for much longer if put up in metal containers filled with nitrogen or carbon dioxide Probably the same method could be used to prevent oxidation of the essential oils of roast coffee beans tea and cocoa nibs

Advantages and Disadvantages of Food Processing Apa from the apathy usual in the public about anything that matter there are two attitudes of mind adopted towards modern foo manufacture out and out condemnation and out and out approva The instinct of one brought up in the country on home killed an cured bacon on home grown vegetables and fruit, on milk butte cheese eggs and poultry from the home farm, and meat killed b the village butcher is to raise his hands in horror at moder methods of food production transport and processing It mus be confessed that in the past—and indeed the present—the sophisti cation of some food e g the tinting of canned peas with anilin dyes the bleaching of flour by oxides of nitrogen, chlorine dioxid and similar reagents, the faking of wines and beers and jams, th use of synthetic flavourings (e g benzaldehyde for almonds) anc the dyeing of kippers leaves a nasty flavour in the mouth metaphorically and actually Nor can the cynical or ignorant attitude of commercial firms in the past, and even *during* the war of 1939–45 be defended Malt is expensive glucose made by the action of sulphuric acid on potato starch is cheap *It* was therefore used in the wort from which beer was made, and poisoned beer addicts within a large radius from the brewery thirty years or so ago because acid was contaminated with arsenic

Public analysts during the second World War have been kept busy analysing catchpenny egg, milk, lemon and other fruit substitutes, "guaranteed to contain all the food values" of the foods for which they were supposed to be substitutes, showing their claims to be unfounded and reporting them to the Health Authorities

The other attitude is to welcome the change because of the much greater variety of foods which can be supplied to our highly urbanized civilization But the modern methods of processing foods demand scientific control—chemical biochemical and bacteriological control—at all stages Until recently the scientist has been but grudgingly admitted into industry and then more often as a subordinate than as a director In the food industry the need for competent biologists as well as chemists, is beginning to be recognized The Food Group of the Society of Chemical Industry has done and is doing much to demonstrate the need for biological control in food manufacture and a journal of the name *Food Manufacture* which reached its majority in 1946 is a welcome evidence of the advance that control is making [1] There are progressive firms in which the biochemist holds a dominating position

It must be recognized that the processing of food is inevitable in an urbanized civilization If the standard of living is to be raised the country must be industrialized and industrialization (though it may not be so in the distant future) entails urbanization The town folk must be catered for with food preserved in some degree or other Consequently it is our task to see that it is conducted as well as may be, and we have to admit if we look at the matter impartially that it has given great advantages For example with milk it has not only raised the keeping quality but it has raised the standard of milk production The milk distributors are as much in favour of clean milk as the most fanatical medical officer of health The same is true of the canning of meat fruit and vegetables The best only are good enough And the time will come when manufacturers will cease to put up a concoction of sugar citric or tartaric acid a coal tar dye and synthetic flavouring and call it a fruit juice

The endeavour to produce a really white flour so decried by food reformers has not been without its benefits Apart from the odd coins trouser buttons and nuts from the combine harvester which have to be removed from the grain before it goes through the rollers in the flour mill there is a not inconsiderable quantity

[1] None the less *Sugar in the Air* a novel by E C Large is not a wild exaggeration

of other seeds some of them even poisonous which have to be removed, and are removed by ingenious machinery Presumably our Norman ancestors ate them in their bread, even in their white bread Processing on the whole, makes for cleanliness—even bacteriological cleanliness—and quality

What are the drawbacks of processing? There can be little or none in the proteins, fats and carbohydrates of the foods It is difficult to believe that the mineral elements are in any way lost[1] It is only in the realm of the vitamins that damage occurs Generally speaking there is little loss of vitamins A and D in processing *though it has been reported that canned herrings have* less of both than the fresh product Vitamin C certainly is decreased in the canning of fruit and vegetables, though as said above, there is often more vitamin C in these than in the same food bought on the open market and cooked at home Probably nicotinic acid and riboflavine withstand processing but vitamin B_1 thiamine disappears either by leaching out, destruction by sulphite or by high temperature in processes such as dehydration and canning As, however goods so canned or dehydrated rarely contain much vitamin B_1 this loss is not serious More serious is it with the cereals Normally the production of a white flour from wheat reduces the B_1 from about 1 I U per gramme to $\frac{1}{4}$ though it should be possible in future by including the scutellum with the endosperms or by breeding special wheats to raise that amount It is said that some of the processes of producing breakfast cereals destroy the vitamin B_1—e g the puffing of wheat and rice—and it is difficult to see how some breakfast cereals can *retain* any of that vitamin though so far as we know actual biological experiments are lacking Processing then, is inevitable it has its advantages and disadvantages the former have raised the standard of food here and elsewhere the latter can with ordinary intelligence be obviated

[1] But see the section on cereals for the welcome loss of mineral elements

[2] 100 grammes puffed shredded and flaked wheat have 5 67 and 13 I U vitamin B_1

CHAPTER VIII

THE COOKING OF FOODS[1]

Many foods in their natural state are quite unfit for human consumption e g cereals pulses, cassava and have to be 'processed' before eating A home 'process' is that of cooking and it has been practised from time immemorial It is possible that cooking was first applied to cereals though there is plenty of evidence that prehistoric man had learnt the value of cooking his principle food viz meat

The object of cooking food is twofold (i) *Æsthetic*—to improve its appearance and to develop in it new flavours Even animals prefer their food cooked (ii) *Hygienic*—to sterilize it to render it more digestible and to evoke during its consumption, greater flow of gastric juice

Cooking meat, fish and milk foods with a considerable amount of protein or fermentable carbohydrate puts off the period when they will "go bad by destroying the microbes which normally bring that about (A wise cook brings the contents of her stock pot to the boil once every twenty four hours) Further cooking destroys many dangerous parasites which may lurk in ill inspected meat[2] It also destroys the toxins manufactured by *bacillus botulinus* but not unfortunately those made by the salmonella group of microbes

[1] See on this subject B Lowe *Experimental Cookery* (London Chapman & Hall 1932) McCance and Shipp The Chemistry of Flesh Foods and their Losses on Cooking *Med Res Council Rep* No 187 1933 and McCance Widdowson and Shackleton *Med Res Council Rep* No 213 1936

[2] Animal parasites found in meat are not capable of withstanding a temperature of 70 C (158 F) All ordinary forms of cooking will therefore render meat free from this source of infection An outbreak of trichiniasis in the Birmingham area of this country in 1941 was due (i) to insufficient inspection of the pork used and (ii) to the habit of the people in this part of the world to eating some of the sausage meat *raw*

Cooking certainly increases the *digestibility of vegetable foods* and is said to improve that of meat, possibly by destroying the antiferments in it and by loosening the fibres Even though the coagulation of the proteins *of meat may render them less* digestible *in vitro* the increased attractiveness of well cooked food may render it indirectly more capable of digestion by calling forth a more profuse flow of psychical *gastric juice*

The application of heat in some form or another being the essential part of all ordinary processes of cooking, it is important to have clear ideas as to the ***effect of heat upon the different chemical constituents of food***

The effect of heat on the ***proteins*** of the food is to coagulate them It would be a complete mistake however, to suppose that a boiling temperature is essential for bringing about this change for *coagulable* proteins, both *animal* and vegetable, begin to coagulate if their temperature is raised to 60° C (140° F) Above that the protein contracts or shrinks in most animal foods though eggs and fish *roes are exceptions* This *shrinkage is accompanied* by a small decrease in digestibility

Of the ***carbohydrates*** of the food starch is the most affected by heat *Dry heat converts starch into a soluble form*, and ultimately into dextrin This change occurs to a limited extent in the crust of bread and also in the making of toast and biscuits Moist heat causes the starch grains to swell, and ultimately to rupture their envelopes, and the starch is then said to be *gelatinized* That this change also takes place considerably below the boiling point of water is known to the laundress or the cook If boiling water be poured on to cold 'blended' flour, starch or cereal, it gelatinizes, although the temperature of the mixture cannot ever be as high as 100° C (212° F) Oat starch is said to gelatinize at 85° C (185° F), and potato starch at so low a temperature as 65° C (149° F)

Here again one sees that in the case of some starchy foods the change which it is the object of cooking to effect can be brought *about* at a *comparatively* low temperature

The effects of heat upon *cane sugar* in acid solution, as in stewed fruits and jams is hydrolysis The cane *sugar is "inverted"* to glucose and fructose The partial conversion of sugar into caramel is one of the means by which flavour is developed in food by cooking

The *fats of food are not so much affected* by heat as the proteins and carbohydrates At high temperatures however, as when one of the dry methods of cooking is employed some at *least of* the fat may perhaps undergo a partial decomposition with the liberation of free fatty acid and acrolein The latter irritates the mucous

membrane Fat which has been heated and allowed to cool again is often found to have become more granular than it was before This change is probably due to the driving off of water, and it tends to render the fat more brittle and consequently more digestible The change is well exhibited in the case of dripping and also in fried bacon

With these preliminary considerations we may proceed to the study of the effects of cooking upon animal and vegetable foods respectively

Cooking of Meat

The ideal to be aimed at in cooking meat is to decompose its red colouring matter (hæmoglobin) so as to remove its raw appearance, and to do this without overcoagulating the proteins of the meat or removing from it its flavouring ingredients (extractives)

We may glance very briefly at the means by which this ideal is to be attained in the ordinary methods of cooking

Boiling It is unfortunate that the term boiling should be applied at all to any method of cooking meat, for it implies that the subjection of the meat to the temperature of boiling water (212° F) is an essential of the process But this for the reasons indicated above is a mistake The red colouring matter of the meat is decomposed and rendered brown at a temperature considerably below that of boiling water, and by raising things to the boiling point one runs the risk of hardening the meat by overcoagulation of its proteins

That the boiling point is not essential for the complete coagulation of the proteins can be most easily proved in the case of an egg If two eggs are taken and one kept in water at a temperature of 80° C (175° F) for ten or fifteen minutes and the other for an equal length of time in boiling water it will be found at the end of the experiment that the contents of both are solid throughout but that in the case of the former they consist of a tender jelly whereas in the boiled egg they are dense and almost leathery Several so called egg boilers indeed have been introduced which work upon the principle of cooking the egg at a temperature considerably below the boiling point of water

Now what is true of an egg holds good also for meat and accordingly the first principle to be observed in the 'boiling' of meat is to see that the temperature of the water does not rise much above that which is required for the coagulation of proteins It is only by giving heed to this that one can achieve the first result desired—the abolition of the raw colour of the meat with avoidance of overhardening

The second object to be aimed at, that of retaining all the flavouring constituents of the meat, also demands some care The flavour of meat is due to its extractives and salts, and both of these are *readily* dissolved by water If the water in which the meat has been cooked is to be consumed in the form of soup, the partial removal of some of these flavouring ingredients *is not of much* importance, but if the meat alone is to be eaten precautions must be taken to prevent their being dissolved out

One way of doing this is to use as *small a quantity* of water as possible, for the larger the proportion of water to meat the greater will be the amount of soluble substances removed *The quantity* of water, therefore, should be just sufficient to cover the meat, and no more

A belief popular in cookery books is that the exposure of meat for a few minutes to the temperature of boiling water creates a *pellicle of coagulated protein on the outside impermeable to the* soluble constituents within Such a procedure with a later lowering of the temperature, has been advocated in order (i) to conserve these constituents, (ii) to continue the coagulation of the proteins An investigation of the premises of this theory shows *them to have no foundation in fact* [1]

A summary of the effects of cooking meat in water, taken from McCance and Shipp's work, is here given

When fully cooked beef is found to lose the same amount of weight, water and salts, whether cooking is begun in hot or cold water

The application of heat over 60° C (140° F) to flesh foods causes a shrinkage of their proteins and the expression of juice When the meat is heated in water there is in addition a minor loss of salts due to diffusion into the surrounding water

The rate of shrinkage is accelerated by raising the temperature, but the final result is but little different whether cooking is brought about by long exposure to a lower temperature or short exposure to a higher temperature though it is slightly increased if the higher temperature is used

Shrinkage is less rapid and less in amount in absolutely fresh killed than in 'conditioned' meat This is probably not due to the formation of lactic acid in rigor mortis

The more rapidly the shrinkage occurs the less important becomes

[1] McCance and Shipp 1933 *Med Res Council Report* No 187 These authors point out that earlier research work has given little support to the pellicle theory since it was propounded by Liebig None the less it has flourished even in 'scientific' articles upon cookery

the loss due to diffusion into the surrounding water The smaller the pieces cooked the greater is the loss due to diffusion With small portions of meat the salt losses are greater when the meat is boiled than when steamed, but with larger portions it makes little difference whether they are cooked in water or in steam

In general if boiling is used to cook meat it makes little difference to the final losses whether the meat is boiled quickly slowly or if the temperature is lowered soon after the beginning of cooking *so long as the meat is cooked to the same degree* Cooking at a higher temperature achieves the result aimed at more quickly but it is easier to over shoot the mark at high temperatures than at lower but adequate temperatures

Roasting In the process of roasting the heat is conveyed to the meat by direct radiation, instead of through the medium of water The effect of roasting upon meat is similar to that of boiling shrinkage occurs, causing an expression of the juices of the meat These, however are evaporated to dryness on the surface of the joint and are therefore not lost as they are in boiling so that roasting, baking and grilling are conservative methods of cooking The greater heat at the surface of the joint brings about a change in the protein expressed and coagulated thereon with the production of more sapid substances and it is to these and the greater concentration of the salts that the outside cuts owe their characteristic flavour The loss of weight in roasting is nearly all due to evaporation but a loss of salts can be increased by reducing evaporation as, for instance by basting

The puffiness of a well cooked chop or steak by grill is to be explained by the greater shrinkage of the outside and more 'overdone' layers as compared with those inside

Baking acts in precisely the same way as roasting the heat in that case being applied all round the meat at once instead of only to one side at a time Connoisseurs prefer roast meat to baked meats

Stewing is in many respects the ideal method of cooking meat If properly performed it coagulates without overhardening the proteins while owing to the fact that the juice is eaten along with the meat, none of the flavouring ingredients is lost At the same time, the prolonged action of heat and moisture converts most of the connective tissue into gelatin so that the fibres readily fall apart and the meat becomes very tender Here again the secret of success consists in avoiding too high temperatures It is not sufficient to place the pan near the edge of the hotplate and allow it to 'simmer instead of boil The use of a thermometer will show that the temperature of simmering and 'boiling'

water is really the same i e 212° F, the only difference being that in the former case the heat is reaching the water more rapidly and more of it is wasted In proper stewing the temperature should not be allowed to rise above 82° C (180° F)

Cooking of Fish

The flavouring ingredients of fish are even more easily dissolved out by water than those of meat, and as fish has less flavour to start with, any loss is the more carefully to be avoided For this reason boiling, unless very carefully performed on the lines above laid down is not a suitable method of cooking fish The experiments of McCance and Shipp show that boiling may result in a loss of 40 per cent of the salts It might be expected that cooking by steam would be preferable, and this is certainly true of small pieces of fish

Frying is a method of cooking specially applicable to some forms of fish, and demands a special word of description especially as the process is so often misunderstood

The essence of frying consists in the sudden exposure of the object to be cooked to a very high temperature This leads to such rapid evaporation from the surface that the loss of salts and nitrogenous matter is reduced to a minimum Such method of cooking naturally adds considerably to the fat content of the final product For example, steamed whiting has 0 9 per cent of fat, whiting with batter and crumbs has 10 3 (McCance and Shipp)

In order to attain this very high temperature some form of fat must be used as a medium Olive oil or good cottonseed oil are best The oil should be heated in a deep pan almost to its boiling point (the actual temperature is about 180° to 200° C—356° to 392° F), and when this temperature has been reached the object to be fried should be lowered gently into the pan, and left for two or three minutes The bubbling which ensues is due to the conversion of the moisture on the surface of the object into steam When this has ceased the cooking will be complete and the object should be lifted out and the excess of oil allowed to drain off

It will be observed that this process differs entirely from the so called "frying" usually practised in this country, in which the fat employed is regarded merely as a means of preventing the object from adhering to the surface of the shallow pan, in which a sort of roasting is really accomplished

Cooking of Vegetable Foods

In the cooking of vegetable foods the objects to be achieved are different from those which one seeks to accomplish in the case of

animal foods Cell wall substances and raw starch are almost incapable of digestion by man and hence the softening and rupture of the cellulose framework of a vegetable food and the gelatinization of its starch grains are the chief ends which it is the purpose of cooking to bring about

Cell wall substances can be softened and, indeed, partly converted into sugar, by the action of acids, aided by heat Nature uses ferments In its unripe state a pear or other fruit is hard and "woody" from the presence of a cell wall framework In process of ripening the acids in the fruit, aided by the heat of the sun and ferments, effect a softening of this framework with partial or complete solution of the cellulose fibres the product being the sweet and soft ripe fruit

This method is sometimes unconsciously imitated by man The process of preparing *ensilage* is an example of it Here under the influence of fermentative bacteria acids are produced in grass which by the aid of moisture and heat, act upon the cellulose and effect a partial conversion of it into sugar In Germany a very similar process is employed in the conversion of cabbages into *Sauerkraut*

The preparation known as *sowans* is an example of the operation of a similar agency on the cellulose of oatmeal Ordinary porridge also when allowed to stand for some time, becomes a soil for the growth of acid forming bacteria and the products of the growth of these bring about some degree of softening of the cellulose in the particles of oatmeal For this reason porridge is often found to be more digestible when stale than when perfectly fresh

Another way of overcoming the cellulose obstacle, which may in a sense be regarded as a process of cooking, is by ***milling*** or ***grinding*** This breaks up the cellulose framework and allows the digestive juices to penetrate into the nutritive ingredients which it encloses

More commonly however one finds the same object accomplished by the combined action of heat and moisture When exposed to moist heat starch grains as we have seen swell up their envelopes rupture and they run together to form a paste or starch jelly As this jelly expands it presses upon and ultimately ruptures the framework of cellulose in which the grains are enclosed and in this way the two chief objects aimed at are achieved The degree to which this occurs is very well shown in the accompanying diagrams (Figs 8 9 and 10) which illustrate the action of moisture and heat upon the structure of a piece of potato

It will be evident from these considerations that cooking is of immense importance in facilitating the digestion of vegetable foods

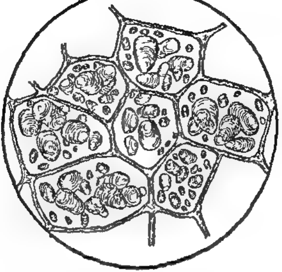

FIG 8.—CELLS OF A RAW POTATO WITH UNRUPTURED STARCH GRAINS AND CELLULOSE FRAMEWORK

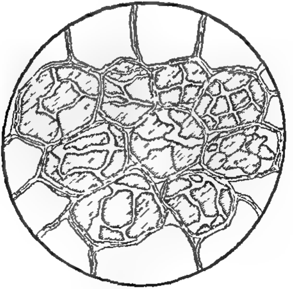

FIG 9.—CELLS OF A PARTIALLY COOKED POTATO THE STARCH GRAINS RUPTURED

and the larger the proportion of cellulose present the more essential does thorough cooking become

Heat has an effect on the *proteins* of vegetables precisely similar to that which it exerts on the same constituents of animal food, that

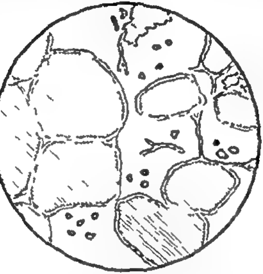

FIG 10 —CELLS OF A THOROUGHLY BOILED POTATO; CELLULOSE FRAMEWORK BROKEN DOWN

is to say they become coagulated Now, the coagulation of proteins is accompanied by shrinkage rather than by swelling and for this reason if the cellulose framework encloses protein only it does not become ruptured, and one can therefore readily understand that if a vegetable food contained protein alone its digestibility would be affected by cooking in a precisely similar way to that of animal food in other words it might be rendered less rather than more digestible by the process The explanation of this apparent paradox is that vegetable foods containing much protein also contain much starch (e g the pulses) and that the starch in gelatinizing ruptures the cell membranes Green and root vegetables contain but very little protein

Losses in Cooking

No matter how carefully cooking is performed, a certain amount of loss of the soluble constituents of the food during the process is inevitable In the case of meat it has been found by Johnston that—

digestion, while the dilution of the vegetable foods after cooking makes less demand on the digestive juices. This, too, is one reason why meat which has been cooked more than once is rather difficult of digestion. Not only are its proteins apt to be over coagulated, but the relative proportion of fat is increased at the same time, and both of these facts militate against rapid and easy digestion.

On the other hand, the increase of bulk which vegetable foods undergo as the consequence of taking up water in the course of cooking is apt to throw a strain on the *mechanical* as opposed to the purely chemical functions of the digestive organs. The bearings of this fact upon the practice of vegetarianism will be discussed in a later chapter.

Slow Cooking

Since food is a bad conductor, heat only penetrates into it very slowly. Wolffhügel and Hüppe,[1] for instance, found that the temperature of the interior of a piece of meat weighing 8 lb. after 4 hours' boiling was only 88° C., or 12° below the boiling point of water. The interior temperature of a roast varied from 70 to 95° C., according to size. Similar observations have been made by Sir Henry Thompson.[2] He found that the temperature close to the bone of a leg of mutton which had been boiled or roasted for some hours was never above 85° C. (186° F.).

Hence it is that, if heat is applied to a piece of meat too rapidly, one simply wastes fuel and runs the risk of overcooking the outer layers. It is far better to allow a moderate amount of heat to act on the meat for several hours, and the longer the time allowed, the lower will be the temperature required, always assuming that it is kept above the coagulation point of proteins, i.e. above 70° C. (158° F.). This is the practice in high class restaurants. Various special forms of apparatus have been invented with the view of economizing fuel, and allowing of the prolonged action of a moderate degree of heat, some of which are certainly not as well known as they deserve to be.

The simplest of these are constructed on the principle of an ordinary water bath, and consist of a double pan, the outer being filled with water which is kept at or near to the boiling point, while the article to be cooked is placed in the inner vessel. The heat only penetrates slowly to the latter, and never reaches the boiling point, while any risk of burning is also prevented. The French "bain marie" is constructed on this plan.

[1] Quoted in U.S. Dept. of Agriculture Bull. 21.

[2] *Food and Feeding*, p. 97. His results have been confirmed by others (see B. Lowe, *op. cit.*).

and two anthracite stoves the Aga and the Esse, are now constructed on this plan but the usual English range remains much as it was when this book was first written

It is interesting to note that the advantages of slow cooking are well known to some savage tribes, and in this respect the civilized cook has something to learn from them This is the method of cooking practised by the Kanakas of the Friendly Islands as described by the late F T Bullen [1]

A hole is scooped in the earth in which a fire is made (of wood) and kept burning until a fair sized heap of glowing charcoal remains Pebbles are then thrown in until the charcoal is covered Whatever is to be cooked is enveloped in leaves placed upon the pebbles, and more leaves heaped upon it The earth is then thrown back into the cavity and well stamped down A long time is of course, needed for the viands to get cooked through but so subtle is the mode that overdoing anything is almost an impossibility A couple of days may pass from the time of putting down the joint yet when it is dug up it will be smoking hot retaining all its juices tender as jelly, but withal as full of flavour as it is possible for cooked meat to be No matter how large the joint is or how tough the meat this gentle suasion will render it succulent and tasty, and no form of civilized cookery can in the least compare with it

No better illustration of the advantages of *slow* cooking could well be found

[1] *The Cruise of the Cachalot* (1898) Smith Elder & Co London 273

CHAPTER IX

HYGIENE OF FOOD

This subject demands a whole book to itself and a slight sketch only can be attempted here We think that even such a sketch should be valuable to the domestic science students who use this book

The subject has a two fold aspect national and personal or domestic The country as a whole and the local authorities are responsible for much of the hygiene of food production, for its final preparation the home the institution, the canteens and the restaurants are concerned There is the provision of a safe water supply still extremely incomplete in country districts and of satis factory sewage disposal, often primitive in many quarters There is the collection and treatment of household waste and the regulation of dumps These all affect food hygiene Further, the authorities have the task of inspecting abattoirs food factories, dairies, bakeries and so on which directly concern food Naturally such an intimate thing as food is influenced by every activity of man

As so much of our food is prepared for us before it reaches the home and as this centralization is increasing and will continue to increase, the national control of food hygiene becomes ever more and more important It is or should be the Government's business directly, or indirectly through the local authorities to deal with the water supply with milk and dairy products, with meat, poultry and eggs In war time a Ministry of Food is essential, and it is *no less essential in times of peace*

National Control of Food Hygiene It is a fact in food hygiene that plain dirt does not matter half so much as contamina tion with pathogenic microbes One of the most dangerous out breaks of typhoid fever in this country originated from a dairy farm near Bournemouth producing high grade milk Contamina tion of milk with cow dung unpleasant as the fact may be is nowhere near so dangerous as contamination of that milk by typhoid microbes from the hands of a farm worker or by tubercle *bacilli* from the udder of the cow

There is no doubt that the Croydon water supply was singularly

free from what people call "dirt" but a chance contamination by a typhoid carrier produced a deadly epidemic None the less the presumption is that cleanliness of water supplies dairies bakeries abattoirs, markets and so on will make for bacteriological cleanliness of the food produced there as well though Stenhouse Williams in his work on clean milk production showed that first grade milk could be produced in a cowshed which would unhesitatingly be condemned to-day

In water supply, Great Britain has led the world, but none the less the two serious outbreaks of typhoid during the decades 1920–30 and 1930–40, those of Malton and Croydon have been due to contamination of the water supply In the example of Croydon as said above, it was by means of a carrier There are people who having recovered from typhoid to all clinical observation never theless carry typhoid microbes around in their large intestines possibly for the rest of their lives They void these every day and carelessness in personal hygiene results in the dispersal of these microbes into food The classical example of a typhoid carrier was "typhoid Mary" of the United States but there have been numerous examples in this country, where typhoid is none the less a very rare disease The case of the Wrexham pork pies circa 1910 presents an interesting phenomenon There was a typical carrier in the employ of the cookshop The microbes from his large intestine infected the gelatine solution used for pouring into the pork pies before baking but because the pies were then cooked, the microbes were killed and there was no outbreak of typhoid None the less there was a severe epidemic of food poisoning traceable to the pork pies, because the typhoid bacilli had produced toxins in the gelatine

Typhoid carriers must never be allowed to handle food and that means that they must not work in abattoirs bakeries, dairies fisheries market gardens watercress beds and the like It is one of the duties of the medical authorities working with agricultural and Home Office authorities, to see that typhoid carriers are not employed in the food industries or around water supplies Nor should they work in towns and cities As these people have to work *on the land* so as not to be a danger to society, it is difficult to see what, apart from afforestation, corn and stock raising they can do Doubtless carriers of other diseases exist for example scarlet fever and these diseases may be transmitted by food In the United States the theory is held that "infantile" paralysis is transmitted by fæces as in infective hepatitis

Milk and cream may be infected with the organisms of bovine tuberculosis undulant fever scarlet fever and typhoid and so

carry it to human beings There are still a considerable number of deaths from bovine tuberculosis in this country (say 2000 per year) and widespread tuberculosis of glands and joints in the young due to the same disease These could be obviated if Government had the courage to make the pasteurization of milk compulsory The other dairy foods, butter and cheese, do not appear to transmit diseases much though cheese in the United States has sometimes been shown to be the cause of an outbreak of food poisoning The duck egg may transmit an enteritis if not properly cooked and it might be worth the while of the relevant authorities to inspect duck farms for such disease [1]

Meat can transmit diseases in two ways (1) it may become infected with microbes of the salmonella group This once thought to happen in the abattoirs through carelessness is now considered to occur in the butcher's shop or home and is due to transmission by rats and mice It has been thought that these microbes produce toxins indestructible by the heat of cooking and it is known that they can grow in the human alimentary tract and produce vomiting and diarrhoea, often of a dangerous nature But as there is no *direct* evidence for these heat stable toxins inspection of meat in the abattoirs will only reduce the risk of food poisoning via meat but it cannot prevent it because the chief source of infection is in the butcher s shop and the home [2] (2) It may be infected with parasites, which if the meat is not 'properly cooked' can be transmitted to man Proper inspection of the carcasses of meat in the abattoirs can eliminate this trouble, so can cooking It will be remembered that an outbreak of trichiniasis in the neighbour hood of Birmingham in 1941 was due to sausage made from pork inadequately inspected and eaten either raw or lightly cooked

Shellfish and watercress beds have been known to spread typhoid Oyster and mussel beds form in the estuaries of our rivers and as a careless civilization wastes its sewage by the convenient method of running it into the rivers it is not astonishing that in the past typhoid has been transmitted via the oyster and mussel Such shellfish beds need the most careful inspection Watercress has to day an undeserved reputation for spreading typhoid Whenever an important person gets typhoid (e g the late Arnold Bennett) it is rumoured that he got it by eating watercress We are not aware of any cases in this country within the last twenty years being attributable to watercress from commercial watercress beds

A reform long overdue in this country is the screening of abattoirs meat and fish markets bakeries and food manufactories and

[1] *Lancet* (1945) 1, 314

[2] Personal communication by Dr C F Dukes

lavatories from flies The house fly has been incriminated in the United States for the spread of typhoid, and is strongly suspected in this country of disseminating summer diarrhœa In the States it is considered as a possible vector of poliomyelitis and in North Africa (El Alamein) of infective hepatitis and bacillary dysentery On any account knowing the haunts of flies it is time that they should go Refuse dumps should not be tolerated

Finally the food manufactories where such edibles as brawn, pork pies potted meat sausages etc, are made need close inspection Food waste in such places encourages cockroaches, crickets, mice and rats—all potential vectors of disease For reasons given above a known typhoid carrier should be not permitted to work in such places and for reasons which will be obvious there should be adequate lavatory accommodation with washhand basins and an abundance of hand towels Operatives should be encouraged to wash after attending to bodily needs The same applies to canteens and restaurants People with sore hands faces and throats should not be allowed to prepare food A recent example is of a woman cutting sandwiches when in the early stage of scarlet fever Some of the eaters of these sandwiches had a subsequent gastro enteritis from the toxins produced by the scarlet-fever microbes some later developed scarlet fever

Of course it is not only the trades and the health authorities who need educating it is the public also One of us (V H M) has seen a string bag of shellfish out of their shells lying on the filthy platform of a London Station and while this edition was under revision a wholesaler, under the noses of the two authors, dumped a load of cabbages destined for a local greengrocer in the gutter in front of the shop Typhoid and paratyphoid are spread by careless ness in personal hygiene

Food Hygiene in the Home By the time food reaches the home it may or may not have picked up pathogenic organisms or developed toxins It might be thought that there is little that can be done in the way of food hygiene That is not true There is always avoidable wastage due to moulds putrefaction of meat soups and fish and the depredations of cockroaches mice and rats In fact there is often a vicious circle set up The failure to use crusts of bread or to clear out the crumbs from bread bins leads to mouldiness of the whole loaves and so on in geometrical progression The same is true of animal life encouraged in kitchens by the lazy scattering of food The more food scattered the more is unwanted animal life encouraged and the more food wasted because of its being fouled by such animals One of us (V H M) has suffered from a serious invasion by crickets encouraged by the

every microbe It is perhaps best to rinse plates, dishes, etc, in hot water after they have been washed with soap and water and leave them to dry spontaneously, rather than to dry them with a cloth The "tea cloths" can easily pass on milk souring and other microbes to the containers It is a good practice in hot weather to steam out any milk can used for unpasteurized milk In the experience of one of us (V H M) this enabled milk to remain sweet which otherwise went sour in less than 12 hours

Finally, it is unwise to adopt an Antipodean plan of letting the household dogs lick the kitchen china clean This has often resulted in the transmission of a parasite that produces a serious disease of the liver And it must not be forgotten that in countries such as China where human excreta are used as manure there is the possibility of infection with ascaris a round worm inhabiting the gut if raw salad vegetables are eaten Investigation among Oriental students in American universities showed that one third of them were so infected If the composting of garden refuse with human excreta becomes at all widespread in this country, it is possible that the same trouble will beset us here Very careful washing of the salads will be essential

In the above, the possibility of the transmission of disease by food has been emphasized—some may say too much emphasized It is certainly true that the emphasizing of the dirtiness of much milk sold in the past has prejudiced people—medical officers of health among them—against milk as a food The campaign for clean milk has worked in the direction of decreasing the consumption of milk There is decidedly a danger in giving the public a fear of microbes, but it has to be faced It is good that the public should understand the ubiquity, the services and the disservices of microbes and how to take advantage of the one and obviate the other Much of the control of the disservices is in the hands of public authorities and this control needs backing by an educated public opinion In the home the control of them is valuable mainly in preventing the waste of food a crime at most times, but particularly so in the present and near future It may reasonably be said however, that the wonder is how little disease is traceable to contamination of food with parasites or microbes but it has to be admitted that when such enemies get under our guard the results (witness the Croydon typhoid epidemic and the outbreak of trichiniasis in the Birmingham area) are sufficiently devastating

CHAPTER X

THE DIGESTION ABSORPTION AND METABOLISM OF FOODS IN HEALTH

Very few constituents of very few foods are in a fit chemical state for use by the body The simple hexose sugars the inorganic salts and the vitamins, possibly also the fats, may pass straight into the blood or lymph stream unchanged and without ill effect Proteins, the disaccharides dextrins starch cannot so pass More over as they occur in foods they are often tied up in cellulose (or rather plant cell wall) envelopes and these envelopes have to be cooked and macerated and triturated to allow the escape of the contents Complex chemical substances like proteins starches and dextrins have to be hydrolysed to simple soluble diffusible crystal loid compounds and these, if useless as such to the body (e g the disaccharides) have still further to be hydrolysed To carry out these triturations, macerations and hydrolyses the body has a series of organs and glands secreting a variety of ferments these processes of trituration, maceration and hydrolysis are termed digestion

DIGESTION

In the Mouth

The mouth stage of digestion is mainly a mechanical one and its object largely protective The food is ground by the teeth to small particles and at the same time thoroughly mixed with saliva hard substances are broken up softened, neutralized diluted and covered with a wrapping of mucus so that on their passage through the alimentary tract they may easily be digested without undue difficulty and without abrading or otherwise damaging the soft walls of that tract Thorough chewing of food is important Without it food may damage the alimentary tract and cannot be adequately digested To bolt food in the manner in which one posts letters interferes gravely with proper disintegration of it and many cases of dyspepsia are kept up if not actually produced, by imperfections of the teeth or dentures

In addition to the neutralizing, *moistening*, and lubricating effect of saliva there is a chemical influence as well *Cooked starch*, of whatever origin, is digested by the ptyalin of the saliva via dextrins *to maltose* Some starches—e g those of rice and maize—are *more* readily acted upon by the saliva than others such as potato starch Raw starch is hardly affected at all

As most animals have *ptyalin* in their saliva and as man presumably passed through the stage when he did not live on cooked plant foods, this ptyalin must be looked upon as a fortunate accident *for* him, or perhaps as "intelligent anticipation" But since it is there, one had best make the best use of *its power of digesting* cooked starches

Porous foods such *as rusks*, into which the saliva can easily penetrate, are more easily attacked than dense and compact masses, such as new bread Moist substances, *too, offer less resistance* than those which are dry In fact the amount of saliva secreted varies among other things with the dryness of the food Dried powdered meat, Pavlov showed, when given to a dog evokes a thin watery and abundant saliva but when given in its original form only a scanty but highly mucous secretion Doubtless something similar happens in man

The amount of saliva varies too naturally and markedly, with the tastiness of the food and with appetite If a person has a strong conditioned reflex for food even if that food be distasteful to the majority of people—e g caviare to the general and durians to the occidental—that food will evoke a great flow of saliva Dehydration of the body shows its first effect in decreased salivation A person who is thirsty cannot produce saliva, a thing worth remembering when feeding a dehydrated person Acidity of food, *certainly*, and a mild astringency, seemingly increase salivation but intense astringency such as that of an unripe persimmon "dries *the mouth* up" Vinegar malt liquors, wines and tea inhibit the digestion of cooked starch by saliva *in vitro* but it is possible that because these substances provoke a salivation *in vivo* their inhibiting effect is overcome

Another important use of saliva which must not be forgotten is that of washing the mouth clean from food particles which would otherwise remain between the teeth and undergo decomposition (Witness the foul condition of the mouth when salivation is suppressed in fever) So important is this hygiene of the mouth that many dental surgeons advise that a meal should end with raw crisp fruit, which stimulates a flow of saliva besides having in itself cleansing properties in view of its detergent action

In the Stomach

Observations of the results of complete removal of the stomach in man have shown that its co operation cannot be regarded as essential to the complete digestion and absorption of an ordinary mixed diet provided the latter is presented to the intestine in a suitable mechanical form. None the less it has several functions to perform

1 To act as a reservoir
2 To bring the swallowed food to a semi fluid form
3 To sterilize the food—at least in part
4 To regulate its temperature
5 To effect a small degree of digestion of proteins
6 To produce (*a*) an intrinsic factor which reacting with an extrinsic factor of the food manufactures a hormone for maturing the red cells of the bone marrow and (*b*) the neurotropic hormone, which normally makes for the well being of the spinal cord.

We shall briefly consider each of these functions separately

1 By ***acting as a reservoir*** the stomach enables us to take our food in considerable quantities at a time i e it renders *meals* possible The practical convenience of this needs no demonstration, but some points connected with the question of meals may again be raised

First it may be asked ***At what intervals should meals be taken?*** Is it better to take several small meals or to consume one's daily supply of food at one or two sittings? The problem will be discussed again later from the point of view of physiological efficiency but here we may treat it from the point of view of physical capacity The one-meal a day man is at a twofold disadvantage (1) he is apt to overburden the mechanical powers of his stomach by the mere weight of food introduced into it at one time (2) some of the food so introduced may be wasted owing to the digestive absorptive and assimilative powers of the alimentary tract and body tissues being unable to keep pace with the flood of material which reaches them all at once

(1) The capacity of the human stomach is very variable both in different individuals and in the same individual at different periods of life On the average it may be estimated as from 2 to 4 pints and in the case of solids at about 2 lb If it be remembered that the total amount of solid food required daily is about [illegible] lb it is evident that if the whole of this were eaten at one meal the stomach would be overtasked and a dilatation of that organ incurred If the stomach is unhealthy it will be unable to tolerate

response as Hawk and Rehfuss have shown in work upon American medical students

Hence the dietitian emphasizes the importance, especially when feeding the sick, of agreeable surroundings, of clean napery and dainty china, and of good cooking in promoting good digestion, and will make a point of consulting the likes and dislikes of patients Hence too the prevalence of the habit of the glass of sherry before dinner, or the cocktail, and the savoury items usually classed on the menu as hors d œuvres

The *second factor* concerned in producing gastric secretion is a chemical one Pavlov was the first to discover that meat and watery extracts of meat produce a secretion of gastric juice even when the "appetite" juice is obviated by feeding the animal through a fistula when it is asleep He also showed that partially digested foods have the same effect Later research has shown that some part or other of these foods acting on the mucous membrane of the pyloric end of the *stomach releases into the blood* stream a hormone, which travelling round the circulatory *system* comes back to the mucous membrane of the stomach and *stimulates* the glands to secretion It is claimed that glucose, alcohol, lactic acid, sodium bicarbonate, saliva, or meat will liberate this hormone Still more potent than meat are extract of meat, albumoses and peptones The hormone may be histamine

The *normal course of secretion* is (i) that there is an appetite juice secreted as the result of a gustatory conditioned reflex This juice is constant in composition, containing hydrochloric acid and pepsin (ii) There is a second prolonged secretion of the glands continuing long after the reflex flow is over as the *result of the* setting free from the pyloric mucous membrane of some *hormone* into the blood stream This second [1] flow will therefore vary with the nature and state of digestion of the food in the stomach The combined results of all these factors will doubtless account for *Pavlov's observation that each food calls forth a response specific to that food*

There are also, in addition to chemical excitants to the flow of gastric juice chemical depressants Fat is a notorious example and was first discovered to be so by Pavlov Later cane sugar has been added to the list by the work mentioned above of Hawk Rehfuss and colleagues This not altogether unexpected result suggests perhaps the disadvantage of sweet things before a meal [2] Iced

[1] According to Ivy there is a still further chemical influence arising from the products of digestion in the small intestine

[2] E g Fruit at breakfast Fruchtsuppe as in Germany and iced melon in this country in hot weather

water and *strong* alcoholic drinks are also depressants Sodium bicarbonate given before a meal stops the secretion of gastric juice, but given with or after a meal increases it The bearing of these facts on the dietetic treatment of hyper and hypo acidity and of peptic ulcers is obvious

Acidity of the Gastric Contents The total amount of hydrochloric acid present in the stomach depends upon the quantity of gastric juice secreted, which may be as much as 700 c c after a large meal. Of the total amount of acid secreted after a meal only a small part remains in the free form, the larger part is in a state of combination with protein The first part of the hydrochloric acid secreted is neutralized by the bases present in the food (e g carbonates) and after these have been neutralized the rest is free to unite with the proteins There is always some free hydrochloric acid over and above that which combines with the bases and protein of the food The average figure for free hydrochloric acid in pure gastric juice is 0·4 to 0 5 per cent Pure juice is difficult to obtain and it is usual to use the figure obtained after a fractional test meal or after giving histamine or alcohol

Bennett and Ryle examined the gastric juice of 100 healthy students at Guy s Hospital using the gruel test meal and found that 84 per cent of the curves for acidity fell between what are called the normal limits of 0 040 to 0 180 grammes of hydrochloric acid (11 to 50 c c of N/10 Hydrochloric acid) with a mean of 0 118 (32 c c) at the end of 1½ hours after the meal, 7 per cent rose a little above 0 180 (50 c c) at that time but began to decrease later like the 84 per cent which were within normal limits 5 per cent exceeded 0 180 grammes at the end of 1 hour and continued to climb (the " climbing curves ') and 4 per cent of the cases showed complete achlorhydria [1] The causes of these individual differences are not clear and none of the students complained of gastric symptoms

The amount of acid begins to decrease after 1½ or 1¼ hours and this decrease is believed by Bolton to be due to the regurgitation of alkaline fluid from the duodenum as the proportion of total chloride to free hydrochloric acid increases about this time except in those patients who have a " climbing curve

The gastric juice then is markedly acid ($p_H = 1\ 6$ to $1\ 8$) and we have to consider the relations of this acidity to (1) the digestion of starch in the stomach, (2) morbid gastric sensations

Digestion of Starch in the Stomach There is no doubt that ptyalin is rapidly destroyed by free acid and that its action

[1] *Guy s Hospital Reports* (1921) 71 286

on starch ceases at about $p_H = 4$ The rate of digestion of starch by ptyalin depends on the concentration of hydrogen ions in the medium It is at its maximum at $p_H = 6.9$ or just on the acid side of neutrality So soon as the combination of protein with acid in the stomach fails to keep the hydrogen *ion concentration* at or beyond this figure the ptyalin digestion of starch falls off When starchy foods undergoing salivary digestion are thoroughly mixed with gastric juice that digestion ceases

It follows then that starchy foods will not go on digesting for long in the stomach, at any rate if they are mixed with the earlier *portions of the meal* in *the later* portions *of the meal* carbohydrate digestion can continue much longer Observations with X rays *have shown that the food last swallowed is received into the centre* of the mass already present in the stomach, and does not for some time come into contact with the gastric juice The central portions therefore can retain an alkaline to mildly acid reaction for a considerable period during which ptyalin can go on digesting the cooked starch This justifies the conventional arrangement of a dinner in which the starchy course (pudding) comes after the protein course (meat)

Relation of the Acidity of the Stomach Contents to Morbid Gastric Sensations In health, digestion proceeds quite unconsciously and without the production of any sensation at all In morbid conditions of the stomach, however digestion may be accompanied by sensations of pain and these seem to arise in at least two ways (1) from disorder of the motor functions of the stomach (2) from abnormal conditions of the mucous membrane

The former of these we shall consider *later* The *latter seem to* be of two sorts (*a*) where the mucous membrane is unhealthy and *is unduly sensitive to the total acidity of the contents*, (*b*) where *free* acid alone produces pain The former of these conditions seems *to* be present where actual lesions of the mucous membrane exist —e g in acute and chronic gastritis ulcer, and in carcinoma, the latter, if it ever occurs is apparently more often of the nature of a neurosis—a hyperæsthesia of the nerves of the mucous membrane though it is possible that in extreme degrees of such hyperæsthesia pain may be produced even by combined acid *Where the* total acidity causes pain the condition is likely to be aggravated by foods rich in protein such as meat for these as *we have seen* call forth an abundance of juice and therefore of acid If on the other hand free acidity *alone excites the sensation* such foods are likely to be beneficial for they delay the period at which free acid appears *and also* lessen its amount In accordance with this explanation it will usually be found that patients who are suffering from ulcers

tion of the stomach complain of pain after meat, but can digest milk with comfort, for milk not only neutralizes much acid by means of its proteins, but in itself calls out the secretion of a weak and scanty gastric juice On the other hand, one usually finds that patients with functional dyspepsia and hyperæsthesia of the stomach suffer less from meat than from foods which, being poor in proteins, allow of the early appearance of uncombined hydrochloric acid These considerations are of importance in helping one to select a suitable dietary for dyspeptics

One other function of the hydrochloric acid is to render some metallic radicles of salts more available Thus calcium phosphate may become calcium chloride and passing down into the duodenum may be absorbed as such Hypochlorhydria may account for a difficulty some people show in absorbing sufficient calcium and iron from normal diet

Movements of the Stomach In studying the movements of the stomach one must distinguish quite sharply between the cardiac and the pyloric end of the organ The two ends are distinct, both anatomically and functionally The cardiac end secretes both pepsin and hydrochloric acid the pyloric end pepsin and the hæmatopoietic substance The former has but feeble motor power the movements of the latter are more powerful

Possibly as the result of Cannon's masterly work on gastric peristalsis in the cat, the amount of movement in the stomach of man has been exaggerated Radiograms purporting to be normal have indicated an amount of movement that we now know to be abnormal. Barclay[1] shows a picture of a normal stomach emptying its contents into the duodenal cap in which there is little or no peristalsis and another where the peristaltic waves are of the mildest, and contrasts these with one where there is excessive peristalsis The latter more closely resembles the normal appearance in the cat Thus both active and quiet peristalsis may occur in health and we do not know yet what determines the one or the other

The stomach is a U shaped cavity with one limb (the pyloric) shorter than the other The cardiac end remains quiescent but towards the pyloric end peristaltic waves may mix the food up but this mixture is not an essential mechanism though it is brought into action if the food contains any large unmasticated lumps The main propelling force must be the intragastric pressure due to the tonus of the muscular walls of the stomach From time to time the pylorus opens and allows food to enter the duodenum and according to Barclay this opening is probably controlled by a

[1] *Amer Journ Roentgenology* (1938) 40 330

reflex mechanism actuated from the region of the ileo cæcal sphincter and is not due to peristalsis of the stomach or to change in the acidity of the gastric contents

The length of time which elapses between the swallowing of food and the first opening of the pylorus is variable, depending chiefly upon the *consistence of the food* and the *temperature of the stomach contents* Fluids, unless they contain much solid matter in suspension, begin to escape almost immediately—water, indeed, whilst it is still being swallowed

Any excess of fluid taken with a solid meal is probably also passed on almost at once, and so cannot seriously dilute the gastric juice Solid food can only escape after it has been brought to a fluid or semi fluid consistency, and this must obviously depend to a large extent upon its physical characters and density

An opaque meal of porridge and bismuth oxynitrate can be seen escaping from the stomach within ten minutes of being eaten, and estimation of the blood sugar shows that it has risen ten minutes after glucose has been taken by mouth and twenty minutes after a porridge meal

The larger part of a meal, however, probably does not pass out of the stomach till most of it has been completely digested, and half an hour after that has taken place the stomach may be regarded as empty

Rate of Digestion of Different Foods The response of the normal human stomach to various foods was first investigated by Beaumont in his *classical experiments on Alexis St Martin* and Penzoldt made careful observations in 1893 From 1912 onward till the subject s death from cancer of the stomach Carlson produced a number of communications concerning digestion in the stomach of Vlček, a Czech, with a surgically made gastric fistula The method of removing small amounts of food at frequent *intervals* after a meal by means of the Rehfuss tube has also given much information There were among the students *investigated* by Hawk, Relfuss and others two types of stomachs—the slow and the quick The slow did not complete its emptying under 3½ hours, whereas the quicker type of stomach was empty in 2½ hours The time which the slow and quick acting stomachs take to empty and the highest total acidity observed are shown in the table on p 235 The results destroy some popular beliefs Thus 100 grammes of beef and lamb were both digested in about the *same time*, 3 hours and 25 minutes for the slow, and 2 hours and 35 minutes for the more quickly emptying stomachs whereas chicken and ham take ten to twenty minutes longer Further roast beef was digested in the same time whether it was underdone (American "rare"), *medium*,

Evacuation Time and Highest Total Acidity for Various Articles of Diet [1]

Articles of Diet (100-gramme portions unless otherwise stated)	Number of Observations	Evacuation Time (Hours and Minutes) Type of Stomach: Rapid Emptying	Slow Emptying	Average	Highest Total Acidity (average) (cc N/10 Alkali to Neutralize 100 c c Juice)	Grammes of Hydrochloric Acid.
Beef and beef products	25	2 35	3 25	3 00	120 0	0 40
Lamb and lamb products	14	2 30	3 20	3 00	135 0	0 492
Veal						
(a) Market	7	—	—	2 50	140 0	0 51
(b) ' Bob	7	—	—	3 20	110 0	0 40
Pork and pork products	31	2 45	3 40	3 15	120 0	0 44
Chicken	20	2 45	3 45	3 15	125 0	0 455
Turkey	2	3 00	3 45	3 30	140 0	0 51
Guinea Hen	2	—	4 00	4 00	110 0	0 40
Fish	75	—	—	2 50	130 0	0 475
Milk						
Cow s 75 c c	3	—	—	1 15	45 0	0 164
400 c c	50	—	—	2 30	100 0	0 365
Mother s 150 c c	5	—	—	1 40	60 0	0 210
225 c c	2	—	—	2 25	90 0	0 328
Gelatin	5	—	—	2 00	70 0	0 255
Egg and egg combinations	90	2 15	3 15	2 40	80 0	0 240
Vegetables prepared in different ways	124	2 00	2 30	2 50	75 0	0 275
Fruits	68	1 35	2 20	2 00	90 0	0 328
Bread and cereals	75	—	—	2 40	80 0	0 240
Cakes	29	—	—	3 00	90 0	0 328
Pies	29	—	—	2 30	90 0	0 328
Puddings	23	—	—	2 20	90 0	0 328
Sugars and candies	28	—	—	2 05	70 0	0 255
Ice-cream	7	—	—	3 15	105 0	0 384
Ices	4	—	—	2 35	65 0	0 238
Nuts						
(a) 25 grammes	11	—	—	3 00	100 0	0 365
(b) 500 grammes	4	—	—	4 00		

[1] Hawk, Rehfuss and Bergheim (1926) *Am J Med Science* 171, 359

or well done Bacon took nearly one hour longer to digest than beef Two eggs, cooked in various ways, were digested ten minutes quicker than 100 grammes of beef Raw eggs left the stomach a little quicker but if they were boiled hard an extra ten minutes was taken Vegetables as a whole left the stomach in two hours but cabbage and asparagus were got rid of in one and a half hours Raw lettuce took only one hour but the addition of sugar, vinegar, and oil, delayed the emptying a little

The observations on the digestion of milk are most interesting and were carried out on one man who had the power of regurgitating small samples of milk at regular intervals The curds from raw *whole milk* were like rubber and as big as a man's thumb, but those obtained when the milk had been boiled for five minutes were soft and no bigger than a pea The curds obtained from pasteurized milk were intermediate in size between those of the raw and boiled milk Those obtained from skimmed milk were much larger and very hard The character of the curd was directly affected by the fat content and the addition of extra cream made the curds considerably smaller, though the stomach took longer to empty

The addition of 2½ grammes of sodium bicarbonate to 500 c c of raw whole milk caused the formation of smaller soft curds though the change was not so marked as that produced by boiling

The observations on pies [1] showed that the pie crust was evacuated in 2 hours 52 minutes, while the fruit portion was got rid of in 26 minutes less time The addition of 100 grammes of sugar delayed evacuation but small amounts (10 grammes) had no effect The figures for the secretion of acid are also surprising The highest figure of 140 c c is given by veal and turkey, whereas beef and pork with 120 c c are below both chicken and fish Eggs and bread produce relatively little, only 80 c c The figures for milk are rather difficult to evaluate, as 400 c c, which is a large amount to drink, caused an acidity of 100 c c while 75 c c (2½ oz) produced 45 c c of acid It seems probable that some of the old observations are correct i e that mashed potatoes are more rapidly disposed of than boiled potatoes, and that old potatoes are better tolerated than new potatoes Firm bread and biscuits are found to be more digestible than new bread but there is little difference between crust, crumb and toast and between new and stale bread, provided all are equally well chewed These observations have not yet been repeated since the introduction of the fractional method of testing the stomach

3 Antiseptic Action of the Gastric Juice Another function which the stomach serves is that of partially sterilizing the food

[1] The American pie is what we should term a turnover

by the antiseptic action of the hydrochloric acid of the gastric juice This action however, is not a powerful one, and some organisms such as those which form acids, seem to escape it altogether, and there is reason to believe that the same is true of some at least, of the commoner pathogenic organisms, notably the tubercle bacillus

The sterilizing power of the stomach must vary greatly according to the period of digestion and the nature of the food. It probably reaches its maximum towards the later periods of digestion, when hydrochloric acid is present in the free state, whilst it is much less or even absent altogether in the earlier stages, when all the hydro chloric acid is in a combined form Food rich in protein by fixing the hydrochloric acid, must greatly lessen the germicidal power of the gastric juice The stomach has little control over the growth of organisms in the intestine The small intestine remains free from putrefactive organisms even if there is achlorhydria in the stomach or indeed when the stomach has been completely removed

4 **The Temperature of Foods and Drinks** One of the minor functions of the stomach is that of regulating the temperature of the food It stands in this matter as a protector of the intestine which appears to be more injuriously affected by extremes of temperature than the stomach itself

The ideal temperature for food is probably that of the body itself Cold food is difficult to digest for it does not excite the stomach sufficiently nor does it possess the stimulating properties of a hot meal It has been said that there is a special craving for alcoholic stimulants on the part of those who are unable to get hot meals, but this is not borne out by observation on Arctic explorers

Extremes of temperature in foods should be avoided as tending to produce local injury to the stomach from 45° to 130° F are probably the limits of safety Many people however are able to take ices and iced drinks with impunity for many years

Drinks at a temperature of 50 C (122° F) make one feel warmer and at a temperature of 7 C (45 F) cooler Wunderlich found that hot punch at 122 F raised the temperature of the body by 03° to 0 1° C for a period of thirty to sixty minutes while half a litre of water at the same degree of heat caused an acceleration of the pulse nearly 20 beats per minute very shortly after it had been swallowed

On the other hand three tumblerfuls of water at a temperature of 45° F produced a lowering of the axillary temperature from 98 4° F to 97 7 F while the pulse rate fell from 70 to 61 per minute [1]

[1] Most of the effects detailed must be due to reflex vasodilatation or constriction of the skin bloodvessels

Digestion in the Small Intestine

When the partially digested food leaves the stomach it enters the first part of the duodenum as a mass where it may remain for

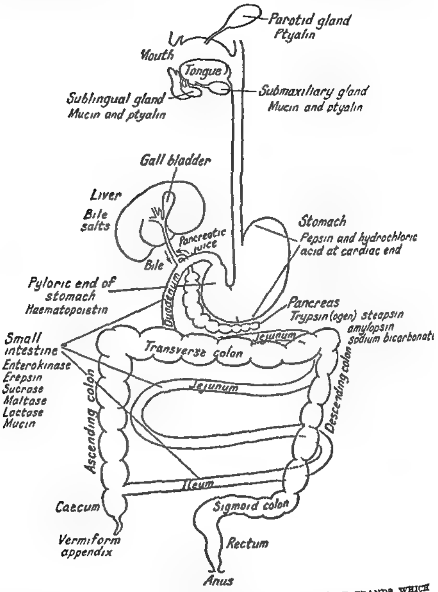

Fig 11 —Diagram of the Alimentary Canal with the glands which secrete into it

a time Ultimately either by being pushed on by newly arrived food from the stomach or by contraction of the circular muscles of the duodenum, it is passed into the second portion of the duodenum

and is there very rapidly "fragmented"[1] Or the fragmentation may be delayed till the food has reached the jejunum This fragmentation, due neither to the segmentation nor to the peristalsis seen so well in animals is probably brought about by the *muscularis mucosæ* and is obviously of great importance By its means the food is brought intimately into contact with the digestive juices poured into the small intestine by the pancreas, by the crypts of Lieberkühn and the liver

The pancreas is partly under the control of the vagus which according to J Mellanby causes it to secrete ferments[2] and partly under the influence of the hormone secretin[3] which dissolved by the bile salts in the bile and absorbed into the blood-stream, causes the pancreas to secrete an alkaline juice low in ferments The crypts of Lieberkühn also seem to be controlled partly by nerves and partly by humoral influences and the same claim is made concerning the contraction of the gall bladder which empties the bile into the intestine

The pancreatic juice contains one potential ferment, and two ferments steapsin and amylopsin The proferment trypsinogen has to meet the ferment enterokinase of the intestinal juice before it is turned into the very active ferment trypsin The intestinal juice contains in addition to the enterokinase erepsin nucleases lactase maltase and invertase while the bile contains bile salt

Trypsin digests either undigested or semidigested protein, breaking into the peptide linkages freeing a good deal of amino acids but not however digesting every peptide linkage In order to bring all proteins to amino acids erepsin is needed to follow up the action of trypsin It is the function of these two ferments to complete the digestion of protein whether or not it has been initiated by pepsin

Fat in the human small intestine is probably hydrolysed by the steapsin of pancreatic juice to glycerol and fatty acid and the latter in the presence of any alkali will become a soap But there is evidence that fat can be absorbed as such in a highly emulsified form

Starch, dextrins and glycogen are hydrolysed by the amylopsin of the pancreatic juice to maltose

Nucleases attack the nucleic acid of the nucleoproteins and disintegrate them into phosphoric acid purine bases carbohydrate and pyrimidine nucleosides lactase attacks the lactose of milk and hydrolyses it to glucose and galactose maltase hydrolyses maltose to glucose and invertase hydrolyses sucrose to glucose and fructose

[1] BARCLAY (1936) *The Digestive Tract* 2nd edn 162 O U P
[2] MELLANBY J (1926) *Journ Physiol* 61 122 419 489
[3] MELLANBY J (1925) *Journ Physiol* 60, [illegible]

Thus in the small intestine all the foods which need digesting are *thoroughly* digested into substances which are crystalloidal (and therefore diffusible), and acceptable to the cells of the body which they are intended to nourish Nothing short of this is of any use and if proteins or polypeptides or disaccharide sugars get into the blood stream they either cause disturbance or are excreted unused in the urine

Absorption in the Small Intestine Practically the whole of the absorption of food stuffs takes place in the small intestine As stated above a small amount of sugar may be absorbed in the stomach, but the amount is almost negligible All the protein as amino acids all the carbohydrate as hexose sugars and all the fat, probably in man as fatty acids and glycerol, which are absorbed, are absorbed in the small intestine So too are the inorganic salts and the vitamins [1] Also at least four fifths of the water drunk is absorbed by the villi of the small intestine In fact that organ is remarkably efficient in the completeness and the rapidity with which it works

As we have seen at least 95 per cent of digestible proteins, 97 per cent of fats and 97 per cent of digestible carbohydrates are absorbed The figure may actually be higher because in making this estimate it is assumed that the protein fat, and carbohydrate in the fæces are derived from the food This assumption is *probably* untrue The nitrogenous material of the fæces may well be derived from secretion of digestive juices and not from the protein of the food and it is not impossible that the fat and carbohydrate of the fæces come from the same source The "fat" resembles the blood lipoids

No physico chemical explanation accounts for the power of the intestinal mucous membrane to absorb materials from its lumen It absorbs what it wants or what the body wants, *despite* osmotic, filtrative and diffusion gradients which may be working in the wrong direction But this is not to say that these gradients *do* not affect absorption Magnesium sulphate exerts a back osmotic pressure because it is not absorbed and thwarts—hence its *aperient* action—the attempts of the intestine to absorb water and substances dissolved in water Meulengracht [2] has even related a failure to absorb calcium from the diet, with a resulting spinal caries, to the use of purgatives Further anything which hurries the contents of the small intestine on their way to the colon, e g a consumption of large amounts of roughage, may prevent the absorption of the normal percentage of the various constituents of the diet This largely accounts for the lowered percentages absorbed from a mainly vegetarian diet Any régime which utilizes large amounts of

[1] But see below p 246 [2] *Lancet* 1938 2, 774

roughage or purgatives will entail (i) loss of nutrient material to the body, (ii) the passage of unabsorbed proteins, fats and carbohydrates into the large intestine, with consequences detailed in later paragraphs

Because the secretions of the pancreas and intestinal glands are alkaline it is often assumed that the contents of the small intestine are alkaline or at any rate neutral This is probably not the case Samples of human duodenal contents show an acid reaction (p_H between 6 and 7) Also observations of patients with intestinal fistulæ suggest that acidity is usual throughout the small intestine [1] One of the functions ascribed to vitamin D is that it enables the small intestine to remain acid throughout its length and thus facilitates the absorption of calcium salts [2] Acidity of the small intestine also increases the absorption of iron This acidity is due not so much to the failure of the glandular excretions to neutralize the acid of the gastric juice as to the growth of acid producing bacilli Through their action upon carbohydrate, acetic butyric, and lactic acids are produced. In intestinal disorders in which there is an extension of the putrefactive alkali producing bacteria of the large intestine there is a case to be made out for increasing the carbohydrate in the diet, or better still adding lactose which is not easily digested and absorbed and therefore passed further down the intestine unabsorbed than the other sugars Recourse too may be had to cultures of *Bacillus acidophilus*, one of the normal inhabitants of the intestine It may be well also to remind the reader again of the value of milk as an intestinal antiseptic

The contents of the small intestine remain fluid throughout its length, water and substances in solution being absorbed at the same or approximately the same rate At the lower end of the ileum the amount of solid matter is only 5 to 10 per cent The advantage of a fluid diet in intestinal ulceration can therefore only be due to the absence from it of things such as roughage which would cause mechanical irritation of the walls of the intestine

Judging from the rate of passage of a meal opaque to X rays the ileo cæcal sphincter is reached 2 to 3 hours after a meal and the cæcum begins to fill at the 4th hour (i.e at the time of the next meal) At the 6th hour the last of the meal is in the ileum Consequently the major portion of the digestion of a meal and the

[1] This generally accepted observation invalidates the theory upon which the Hay diet is based

[2] By this we do not mean that calcium cannot be absorbed from an alkaline small intestine A positive calcium balance was observed by one of us (G G) in a case of renal rickets when the patient was given heavy doses of alkalis and a large dose of vitamin D

absorption of the whole of it is accomplished in the 3 to 4 hours the meal is in the small intestine

Digestion in the Large Intestine

The contents of the lower end of the ileum pass on into the colon at times related to the taking of the next meal There is a growing belief that the different parts of the alimentary tract are nervously integrated Thus the ileo colic sphincter is thought to open when a new instalment of food passes into the stomach at a meal, and there is some evidence that the pyloric sphincter is also integrated with the ileo colic Be that as it may, the cæcum begins to fill 4 hours after a meal at the 6th hour the head of the meal is at the hepatic flexure but its tail is in the ileum At the 10th hour all has passed the ileo colic sphincter and may be in the sigmoid colon ready to be evacuated, or the residue of the meal may accumulate in the transverse and descending colon and only reach the sigmoid colon in the 20th–24th hour These are of course average figures only—there are great individual variations particularly in the rate of passage through the large intestine Often the indigestible debris of the evening meal (e g tomato skins) may be voided the next morning i e 12 hours later, and the sigmoid colon reached decidedly earlier

It will be noticed that there is a considerable slowing up of the rate of passage of the meal in the large intestine Whereas the first two thirds of the alimentary tract may be traversed in 4–6 hours the remaining third *may* take 18–24 hours Indeed it does by no means follow that all the debris of a meal will be voided either 24 hours 48 hours or 72 hours afterwards

The rate of passage through the large intestine is normally increased by vegetable foods either by the mechanical stimulus due to their coarse indigestible fibres or by chemical breakdown products of vegetable cell walls and this has led to the erroneous belief that constipation can be invariably relieved by "roughage" There are colons along which the passage of food debris etc , is slow because they are atonic (the lazy colons) and colons which allow but slow passage because their circular muscles enter into a spasm (the spastic colons) Roughage still further delays the passage of fæces along spastic colons X ray examinations—which according to Barclay are the only certain means of judging (*a*) whether constipation exists and (*b*) its nature—whether atonic or spastic—show that in from 30–50 per cent of cases examined the constipation is due to spasticity Hurst states that the spastic colon is five times as frequent in females as in males

Antiperistaltic movements in the ascending colon forcing material

back into the cæcum, so commonly seen in animals, are absent in the normal human being The only movements seen are (i) a very slow, small, to and fro movement within each haustral segment, and (ii) sudden 'mass movements,' as first described by Hurst and by Holzknecht These latter are important They occur perhaps three or four times a day immediately after a meal. As a preliminary the haustrations of the colon disappear and the colon walls are relaxed Then the circular muscles (presumably) contract, beginning proximally and sweep the column of intestinal contents in front onwards it may be, for a couple of feet or more The movement dies out, and the haustrations reappear The 'mass movement may carry the colonic contents down into the sigmoid colon and on into the rectum, thus sounding the 'call to stool' It is probable that these mass movements are related to the taking of a meal and account for the 'call to stool which so frequently is felt soon after breakfast or, failing breakfast, one of the other large meals in the day

As said above the contents of the ileum are fluid—they contain some 90 per cent water Much of this water is abstracted as these contents pass into and down the colon and the fæces when formed and voided contain about 50 per cent If the passage has been quick along the colon the fæces will be more fluid and if slow more solid So long as the diet has been digestible the composition of the fæces is remarkably constant, though the diet may be very varied as regards content This points to the fæces being derived rather from secretions of the alimentary tract than from unabsorbed food

But if the diet has been indigestible has been taken in excessive amount or swallowed too rapidly for thorough chewing or if the food has been hurried along the alimentary tract by drugs irritability of the gut roughage or food poisoning undigested and un absorbed products of digestion will pass into the colon Here they form a fine pabulum for the bacterial flora of the large gut Proteins and amino acids may be broken down and deaminated or decarboxylated to phenols indol, histamine, tyramine, etc Carbohydrates may be converted to marsh gas, hydrogen, butyric and lactic acids and fats to fatty acids and glycerol The products of protein decomposition are poisonous if (i) they get into the blood stream and (ii) they escape the detoxicating influence of the liver There is little evidence that they ever do but upon the imaginary evidence that they do were based the mutilating operations on the large gut during the opening years of this century and all the food and medical fads which are centred on the view that the large intestine is a poisonous cess pool The undoubted secondary symp

toms of constipation—raised blood pressure headache nervousness, evil taste in the mouth and foul breath—are due to distension of the colon and not to toxæmia

If there are formed elements in the fæces, apart from the large numbers of dead microbes it is a sign of unsatisfactory digestion Muscle fibres of the meat eaten should not be present If they are, food has been bolted or eaten in too large amounts, or peptic and pancreatic digestion is poor If starch grains are found it means either that the starchy foods were not properly cooked or that they were hurried along the gut by roughage and purgatives or were enclosed in vegetable cell walls

In any case incomplete digestion and absorption of foods in the small intestine makes for offensive fluid stools and intestinal distension The bearing of this upon dietetic habits, cooking, and dietetic hygiene is fairly clear

Until 1940 research had shown that the large intestine absorbed nothing but water and glucose from its lumen and the possession of such an organ has been somewhat of a puzzle to biologists The bird has practically none the carnivores a short one and the herbivores one much longer Man is in an intermediate position His intestine is sterile at birth but within a very few hours it is invaded by microbes If these are dangerous as Metchnikoff and others have thought, why has such an organ been retained ? Others have maintained that the microbic flora of the large intestine serve a useful purpose, though it was shown by Nuttall early in this century that guinea pigs can be reared under conditions in which their large intestines remain sterile Since 1940 evidence has been accumulating that the flora of the large intestine manufacture vitamins of the B complex that these pass into the fluids in which the microbes are being cultured and are absorbed into the blood stream Thus man can absorb at times sufficient thiamine, riboflavine nicotinic acid and probably the other moieties of the B complex from the incubator formed by his large intestine At any rate these moieties from the large intestine are a very useful supplement of those taken in the food Confirmatory of these observations are the fact that thiamine, riboflavine and nicotinic acid can be rapidly absorbed from enemata [1] Microbes of the large intestine can also manufacture vitamin K in adequate amounts for absorption

Consequently we may consider this production and absorption of vitamins an important function of the large intestine acting as an incubator for commensal microbes, and we can also see a danger

[1] NAJJAR *et al* (1943 and 1944) *J Amer Med Ass*, **123**, 683 and **126**, 357 cited *Lancet* (1944) **2**, 854

in removing it surgically, using bacteriostatic chemicals which will depress the activity of these microbes or adopting a freak diet which may alter the nature of the intestinal flora

Until recently it was believed that the large intestine is an excretory organ for excess of calcium phosphorus and iron in the blood but to day this view is discredited as the result of a long series of experiments by McCance and Widdowson[1] Any of these elements found in the fæces are there because either they have not been absorbed from the alimentary tract or have formed a normal part of the succus entericus

A summary of the digestion of a mixed meal may serve to gather up a number of the scattered facts which have been mentioned in the preceding paragraphs

The complex sensation called ' hunger impels one to seek food The sight and smell of the food awakens the sensation of appetite,' and with it there begins a flow of digestive juices most marked in the case of the stomach The soup which usually forms the first course, by virtue of its warmth and of the extractives which it contains accelerates and increases the secretion of the gastric juice The solid part of the food is chewed to a pulp in the mouth and unless acid substances are mixed with it, part of its starch is changed into maltose Arrived in the stomach it encounters the ' psychic " juice already secreted, the acid of which combines with the proteins of the food In this way the acidity of the stomach contents is kept down and the action of the saliva upon the starch is allowed to continue As the solids become digested by the ' psychic ' juice their chemical constituents are set free and themselves begin to excite a secretion fitted for their own digestion

Meanwhile the acidity of the contents goes on increasing and brings to an end any further action of the saliva upon starch, it kills or paralyses many of the organisms swallowed with the food while at the same time the peristaltic movements of the stomach begin Under the influence of these the gastric juice and the food are mixed, and the temperature of the mass adjusted to that of the body As digestion proceeds the semi fluid part of the contents along with any excess of fluid which has been swallowed, finds its way into the pyloric end of the stomach, and by the systolic contractions of the latter is propelled into the duodenum This process continues for about 4 or 5 hours by the end of which time the stomach is again empty During all this time the absorption of alcohol and minute quantities of peptone sugar and salts has been taking place

[1] See for example McCance and Widdowson (1937) *Lancet* 2, 680

Arrived in the duodenum, the food encounters the secretion of the pancreas already called out by psychical influences via the vagus, and now increased by the action of the hormone secretin. Here digestion is completed, and as the food is carried along the small intestine its constituents are rapidly absorbed into the blood or chyle. During this time certain bacteria, which have escaped the action of the gastric juice, are busy breaking up any carbohydrates which may be present, producing from them organic acids, which restrain the putrefaction of the protein constituents of the food that would otherwise be apt to occur. The fluid poured out by the glands of the small intestine in the attempt to neutralize these acids partly makes up for the absorption of water and causes the contents of the ileum to remain fluid until the large intestine is reached. The absorption of the digestion products of protein, fat, carbohydrate together with water, inorganic salts, and vitamins takes place in the small intestine. Beyond this point the production of acids ceases, and the rapid absorption of water causes the contents to assume a solid form, while putrefactive bacteria are able to grow unchecked save by the products of their own activity. Vitamins of the B complex are made by microbes in the large intestine, pass out into the substrate and are absorbed. Finally the residue is expelled in the form of fæces usually from 8 to 24 hours or more after the food was swallowed.

The respective *influence of exercise and rest* on the processes of digestion is disputed. Beaumont, from his observations on St Martin came to the conclusion that *gentle* exercise aided digestion and Hellebrandt and Miles, a hundred years later[1] agree, finding that moderate exercises before a meal increases the acidity of gastric juice, moderate exercise after a meal decreases it, and exhausting exercise before a meal seriously decreases it. The whole question is probably one of blood supply. Gentle exercise, by increasing the rapidity of the circulation, may aid the secretion of digestive juices and stimulate the movements of the stomach. *Severe exercise* on the other hand, by diverting much blood and nervous energy to the muscles may be expected to have an adverse effect.

On the whole one can agree with King Chambers that the best employment after a heavy meal is "frivolous conversation" which keeps the heart active without making great demands upon the brain. Rabelais, Chaucer, and even Solomon may be interpreted in the same direction.

[1] *Amer Journ Physiol* (1932) 102, 258

Metabolism of the Products of Digestion of Food

For a thorough understanding of the principles of dietetics as applied in treatment a few paragraphs upon the metabolism of proteins fats and carbohydrates are essential For reasons which later will become obvious we will start with the *Carbohydrates*

These enter the bloodstream from the lumen of the small intestine in the form of the hexose sugars glucose fructose, and galactose If lactose gets into the general circulation as the result of the activity of the mammary gland during lactation, it is excreted by the kidneys

These sugars reach the bloodstream via the portal vein and it used to be stated that in health they were all absorbed by the liver and that the sugar in the systemic blood was not increased after a carbohydrate meal This hypothesis was disproved as soon as it was possible to estimate the sugar in small amounts of blood, 0 1 c c to 1 c c instead of 10 to 20 c c and therefore to collect the blood at frequent intervals after the meal. We now know that the fasting value of the blood sugar varies from 0·08 to 0 12 per cent and is the same in the arterial capillary, and venous blood The sugar begins to increase in the blood within 10 minutes after a dose of glucose and a little later after a carbohydrate meal, and usually reaches a maximum after 30 minutes This is about 0 18 per cent in the capillary blood, say of the finger and about 0 15 per cent in the venous blood of the arm vein The blood sugar either returns to the fasting value within 1 hour or at the most 2 hours and the amount in the capillary and venous bloods are once more identical The difference between the capillary and venous blood after a dose of sugar suggests that the sugar is being stored in the muscles of the limb This is confirmed by the experiments of Burn and Dale [1] and Best Hoet and Marks,[2] on a decapitated dog which had been completely eviscerated except for the liver They found that when insulin and sugar were added to the defibrinated blood the sugar disappeared from the blood and was laid down in the muscles as glycogen

The mechanism by which the sugar is laid down as glycogen in the liver is not yet clear Goldblatt showed that when sugar and insulin were given to young rabbits the glycogen was deposited in the liver but showed that this only occurred in very young rabbits If however adrenalin was given to older rabbits simultaneously with the sugar and insulin glycogen was then laid down in the liver

[1] BURN J H and DALE H H (1924-25) *Journ Physiol* 59 164
[2] BEST C H HOET J P and MARKS H P (1926) *Proc Roy Soc London* Series B 99 32

The path of fructose must be different from that of glucose, for the rise in blood sugar after 50 grammes is not so great as after 50 grammes of glucose. If the blood sugar rises more than 25 milligrammes it is believed that the liver is damaged. This suggests that the fructose is taken up by the liver as it passes through the portal veins in the liver and that only the excess appears in the peripheral circulation. Similarly galactose is rapidly converted into glycogen in the liver, but there is some evidence that the glycogen made from galactose contains 18 glucose units as against the 12 unit glycogen made from glucose.[1]

The belief that glucose, fructose, and galactose play different parts in the body is supported by the observation that the hypoglycæmia produced by insulin cannot be relieved by fructose or galactose, though *glucose at once causes the disappearance of the* symptoms.

The carbohydrate eaten and absorbed is partly used for supplying the energy of the muscular contraction and any excess is in some way transformed into fat, presumably in the liver, and then laid down in the fat depots, etc.

This does not concern us here any more save to say that in the transformation, a good deal of carbon dioxide is eliminated and excreted by the lungs thus raising the respiratory quotient. That used for the production of energy is transferred to the tissue which needs it by the bloodstream and there it is oxidized to carbon dioxide and water, step by step by a series of enzymes and co-enzymes, involving vitamin B_1 and possibly riboflavine and nicotinic acid.

In the absence of insulin, the internal secretion of the pancreas, the sugar cannot be laid down in the muscles as glycogen and in some way not understood, the oxidation of the sugar is unable to proceed.

In the absence of vitamin B_1, the oxidation is only able to proceed as far as the stage of pyruvic acid and then ceases.

The end products of normal carbohydrate metabolism are carbon dioxide and water and these can be very easily eliminated from the body. Sometimes it is true that an intermediate product escapes into the blood and is in part secreted by the kidney. For example, in violent muscular exertion some of the lactic acid, which is an intermediate product of carbohydrate metabolism, gets from the muscles into the blood and though it should be taken up by the liver and transformed into glycogen again *some of it is excreted* by the kidney and so wasted. Also the kidney is involved in the

[1] BELL (1935) *Biochem Journ* 29, 2031 (1936) 30, 2144. See also STEWART and THOMPSON (1941) *Biochem Journ* 35, 245.

excretion of pyruvic acid in beri beri In diabetes the kidney is involved in a twofold way First it must remove the excess above the threshold of glucose in the bloodstream and secondly it removes the acetone bodies which are due to an arrested metabolism of fat, because metabolizable carbohydrate is needed for the complete oxidation of fat and in diabetes the carbohydrate is not completely metabolizable

Fat Metabolism

Fat is needed for two purposes (i) as fuel (ii) because it provides the necessary fatty acids for the manufacture of the lipines, e g lecithin, which forms so indispensable a part of nervous tissues, blood cells and other cells

Sixty per cent of the fat absorbed from the small intestine passes by way of the lymph channels (lacteoles lacteals, and thoracic duct) into the venous blood in the left subclavian vein It thus avoids the liver on its first circuit of the circulatory system and may in part be laid down in the fat depots for later use When pork fat is eaten pig fat is laid down in the fat depots when mutton fat is eaten fat characteristic of the sheep is laid down in those depots[1] Fat manufactured from carbohydrate has more of the nature of the fat that characterizes the animal eating the carbohydrate What happens to the remaining 40 per cent is not accurately known It may also go via the lymph, or it may go direct to the liver The most modern view is that the hydrolysed part of the fat travels via the portal vein whereas the unhydrolysed fat reaches the blood stream via the thoracic duct Anyhow, after a meal containing large amounts of fat, the general bloodstream becomes milky and the liver contains an excess of fat visible under the microscope and estimable by chemical analysis

Almost certainly the lipines are manufactured in the liver and almost certainly fatty acids undergo many of the steps in their oxidation in the liver Probably the fatty acids are broken down by two carbon atoms at a time to form acetic acid and the next but one lower homologues Thus it is presumed that stearic acid is oxidized via aceto palmitic acid to acetic acid and palmitic acid

$$\underset{\text{stearic acid}}{C_{17}H_{35}COOH} + O_2 \longrightarrow \underset{\text{aceto-palmitic acid}}{C_{15}H_{31}COCH_2COOH} + H_2O$$

$$C_{15}H_{31}COCH_2COOH + H_2O \longrightarrow \underset{\text{palmitic acid}}{C_{15}H_{31}COOH} + \underset{\text{acetic acid}}{CH_3COOH}$$

[1] This is not absolutely true SCHOENHEIMER (1942), *The Dynamic State of Body Constituents* has shown that even in the fat depots, those apparently secluded parts of the circulation an interchange continually takes place between circulating fats and depot fats and within the depots marked changes occur

This continues until butyric acid $CH_3CH_2CH_2COOH$ is reached which is oxidized to aceto acetic acid as in the parallel case of stearic acid but then the mechanism breaks down if there be no carbohydrate in the liver or if there is no insulin present to enable the carbohydrate to burn the aceto acetic acid The latter either passes as such into the bloodstream *or is reduced by the liver* to β hydroxybutyric acid These are excreted in the urine and in the urine the aceto acetic acid passes spontaneously to acetone This spontaneous change also occurs in the blood

The three substances β hydroxybutyric acid, aceto acetic acid and acetone are called the ***acetone bodies*** The acetone is excreted by the lungs and is noticeable in the breath as a smell of sweet apples In mild cases of *ketosis* the name given to the state when acetone bodies are being excreted, more aceto acetic acid than β hydroxybutyric acid is present in the urine but in the more severe stages the β hydroxybutyric increases and forms about 70 per cent of the total acetone bodies in the urine [1] Very small amounts of acetone are present in freshly passed urine, but they rapidly increase when the urine stands in a warm place owing to the spontaneous breakdown of the aceto acetic acid [2]

In any state when a large amount of fat is being metabolized without sufficient carbohydrate 'to take care of it' a ketosis results Such states are

(1) When the amount of carbohydrate in the diet is very small, or when the amount of fat in the diet is very large and only moderate amounts of carbohydrate are eaten

(2) When the patient is vomiting a great deal e g in (a) cyclical vomiting of children, (b) toxic vomiting of pregnancy, (c) post anæsthetic vomiting and (d) vomiting in the course of zymotic diseases in children

(3) In severe diabetes when the blood contains an excess of sugar which cannot be used for the burning of the fatty acids

Whenever, then we want to check a ketosis we either give large amounts of cane sugar fructose, or glucose by mouth or we make the blood sugar more available by giving insulin If necessary glucose may be injected intravenously In the case of diabetes mellitus we give a sufficient amount of insulin to ensure that the sugar is used

If we wish to provoke a ketosis as in epilepsy and cystitis we greatly increase the fat in the diet and decrease the carbohydrate

[1] KENNAWAY (1914) *Biochem Journ* 8 355
[2] FOLIN (1907) *Journ Biol Chem* 3 177

For this purpose diets with as little as 10 grammes of carbohydrate per day have been devised See p 607

Protein Metabolism

The proteins are absorbed as amino acids and pass to the liver If carbohydrate has not been taken at the same meal these amino acids are used as fuel (exogenous protein metabolism) [1] If they are accompanied by carbohydrate they pass to the tissues other than the liver and are transformed into tissue protein or into nucleo protein or into substances such as creatine and adenylic acid used in muscle metabolism (endogenous protein metabolism)

In *exogenous nitrogen metabolism* the amino acids are deaminated in the liver and transformed either into glucose or into fatty acid An amino acid such as alanine will be transformed into glucose by a series of steps simply (probably much too simply) indicated thus

$$\underset{\text{alanine}}{2CH_3CHNH_2COOH} + 2H_2O \rightarrow$$
$$\underset{\text{lactic acid}}{2CH_3CHOHCOOH} + 2NH_3 \rightarrow \underset{\text{glucose}}{C_6H_{12}O_6} + 2NH_3$$

More than half the nitrogen of the protein of exogenous nitrogen metabolism passes by this path The remainder passes by the fatty acid path to butyric acid thence to aceto acetic acid and if there be carbohydrate available to carbon dioxide and water The ammonia formed by each deamination is transformed in the liver to urea which passing into the bloodstream is excreted by the kidney in the urine Thus one *main product of exogenous protein metabolism is urea* The kidney also plays a rôle for if healthy it is capable of either making ammonia or taking it up from the blood in order to neutralize the acids which have to be excreted by the kidney When the kidneys are damaged by a chronic interstitial condition it loses this power and the patient may develop an acidæmia [2] Two pathological products of exogenous protein metabolism are *glucose* and acetone bodies, as in severe diabetes

We have considered in a previous chapter in the section on acid base equilibrium two other end products of exogenous protein metabolism—phosphoric and sulphuric acids

[1] It will be remembered that the distinction between endogenous and exogenous protein metabolism is not quite so clear as it once was None the less the older and simpler account of protein meta bolism is satisfactory for the purposes of practical dietetics

[2] LINDER G C (1926–27) *Quart Journ Med*, 20 283

Theoretically, the best plan is to train on a simple and sufficient diet so that the liver and muscles have their full complement of carbohydrate to rest well for a day or so before the contest on a light diet with plenty of carbohydrate to avoid any depletion of glycogen as the result of nervousness and perhaps to take sugar, as described above, shortly before the race Theoretically too we should expect an increased need for vitamin B_1 and according to Abrahams [1] this vitamin does seem to enhance efficiency There is no case to be made out for strict vegetarianism for athletes (it increases flatulence and therefore a tendency to "stitch"), but many long distance cyclists claim that normal vegetarianism, which allows milk, eggs and cheese is advantageous Fluid should not be restricted but, according to Abrahams enough [water or at least a very bland liquid] should be permitted to make a meal enjoyable, larger quantities may be taken when the stomach is empty on rising between meals and on retiring Alcohol is quite unnecessary to the athlete'

Mental work influences the amount and nature of the food required in a very different way from muscular labour It was once believed that the metabolism was raised by some 10 per cent by mental work But Atwater [2] in a careful experiment, came to the opposite conclusion A man was confined in a respiration calorimeter for a number of days and on certain of them he engaged in the severe mental work of reading a German treatise on physics The subject of the experiment was an intelligent person who fully understood the nature of the experiment, and did not shirk mental application It was found that on the working days bodily waste was no greater than during rest

Benedict and Carpenter,[3] in their study of twenty two young men during examinations found their metabolism but very slightly higher than when they were performing an equal amount of work that required no mental effort Grafe [4] concludes in reviewing the work on this subject that intense mental effort probably has a positive influence on metabolism but that so far there are too few experimental data to warrant a definite conclusion

The next point to stress is that ***there is no special brain food*** Büchner gave utterance to the dictum, 'Without phosphorus there is no thought This is only true in the sense that the brain contains phosphorus and without the brain thought

[1] *op cit*

[2] U S Dept of Agriculture Bull 44 1897

[3] Benedict and Carpenter (1909) U S Dept of Agriculture Bull 208

[4] *Ergeb der Physiol* (1923) 21 Part 2 1

as we know it, is unthinkable But it has never been shown an increased supply of phosphorus in the food is specially favou to mental effort, nor, indeed, has that been proved for any food It requires, of course, no special demonstration that ill nourished brain is not one from which good work can be expecte for the brain, like every other organ, demands for its work an abundant supply of healthy blood, and there is, perhaps, no part of the body which is more sensitive to any impoverishment of that fluid On the other hand, any over supply of food must be equally unfavourable to mental work A large amount of food implies a large amount of work on the part of the digestive organs, and that, in its turn, implies a large diversion of blood to the alimentary tract But if more blood is required in the abdomen there must be less left for the brain and the activity of the latter declines, as is evidenced by the feeling of lethargy which is familiar to everyone after a large meal It comes then to this that *the digestibility of a food is of far greater concern to a brain worker than chemical composition* Small and rather frequent meals of ily-digested food is the ideal to aim at The necessity for is is the more apparent when one remembers that brain work is usually also sedentary work Compared with the diet of muscular labour, therefore the diet for mental work should be small The reduction should probably affect carbohydrates and fats more than protein for it is the two former, as we have seen, which tend to be specially made use of as energy foods The protein consumed should be derived to a large extent from animal foods for these are its most compact and digestible source Hence it is that it is far easier for a man who is performing bodily labour to be a vegetarian than for one who is engaged in mental work Whether an abundant supply of protein has *per se*, an actually stimulating influence on the brain must be left undecided though such a view is not without its supporters

Rest, as is implicit in the paragraphs upon basal metabolism and its relation to total metabolism requires much less food than work As we have seen the basal metabolism of an average man is 1680 Calories per day This could probably be covered by an intake of food yielding 1900 Calories or at the most 2000 This is a fact of great value in medicine We can cut down the work not only of the alimentary tract, but also of heart kidneys and lungs by 33 per cent simply by putting the person to bed It explains too why it is that it is so much more easy to fatten a patient when at rest in bed than when up and about for in the former condition the demand both for heat and energy is greatly lessened and any surplus of supply can be diverted to laying down of fat or producing growth It

is notorious that a time in bed induces growth in children The food given during a rest in bed should be of the same nature as that adopted for mental work simple, digestible and given frequently in small amounts

The dietetic requirements of ***old age*** are just the reverse of those of childhood The assimilative power of the cells is on the wane and the bodily activities are restricted hence less food is required The danger of overfeeding the old is almost as great as that of under feeding the young, an excess of nourishment chokes instead of feed ing the flickering flame of life Leanness and longevity go together, and a man will only roll all the faster down the hill of life if his figure be rotund "Discerne, says Bacon "of the coming on of yeares, and think not to doe the same things still, for Age will not be defied" and one cannot with impunity continue to 'doe the same things' in matters of diet any more than in anything else

The problem is to know how much to take and when old age may be considered to start The basal metabolism of a number of men of an average age of 80 was only 10 per cent below the normal [1] This figure gives us but little guidance to the total metabolism of old men because of the lessened muscular activities of the aged Figures quoted in earlier editions showed 2149 as the Calorie intake, or about 0 7 of the average man And this figure is being adopted in recent work concerning the Calorie intake of British families and may well form the tentative basis of any future work

As regards when old age begins it is difficult to say Judging from the failure of eyesight and the onset of the menopause old age begins about 45 Tissue metabolism is at its highest point in very early life, so perhaps we may date senescence from 18 months! The curve of basal metabolism falls slowly from its figure of 40 Calories per square metre at 21 years to 35 or 37 at 70 years In other words, the transition from the metabolism of youth to that of old age is a gradual and insidious process and our food intake should, ideally in its transition be as gradual Otherwise obesity is apt to descend upon us as we give up our exercise and resign our bodies to the arm chair and the motor car The fact is that if we are temperate and never continue eating when hunger is satisfied we shall insensibly adjust our intake to the needs of the body

Luigi Cornaro is one of the most eloquent advocates of temper ance in old age It cannot be urged too often,' he writes,[2] 'that when the Natural Heat begins to decay 'tis necessary for the pre servation of health to abate the quantity of what one eats and drinks

[1] Du Bois *op cit* p 152

[2] *Sure and Certain Methods of Attaining a Long and Healthful Life* translated from the 4th edition London, 1727 91

every Day, Nature requiring but very little for the Support of the Life of Man, especially that of an Old Man" He tells us that he ate only 12 oz of solid food daily, consisting chiefly of bread, wine, broths and eggs, veal mutton, partridges chickens and pigeons, and some kinds of fish, such as pike for all of these aliments' he adds "are proper for old men" His system was certainly justified by its results for he is said to have lived to be a hundred years old

Woman requires less food than man Her maximal rate of out put of energy is smaller than man's Her basal metabolism is lower We should therefore expect her total metabolism to be smaller and observation confirms this expectation Whereas Lusk allows 2500 and the Technical Commission of the League of Nations allows 2100 Calories per day, the average figure for English women is as we have stated above 2100 Calories

We have no particular recommendations to make concerning the diet of women save that there is no need to depart from the general principle of making sure of the protective foods Woman probably needs as much of these as man She needs rather more iron containing foods than man and generally speaking her food should be more digestible

Pregnancy and Lactation Probably more data on the necessary diet for these two states has been acquired in the last decade than on any other dietetic subject This is very desirable in view of maternal mortality which almost certainly might be considerably reduced, and the infantile mortality which though much lower than in the years before the war of 1914–18 has by no means reached the irreducible minimum Some rather crude experiments in feeding expectant women carried out in the depressed areas of Wales by the Birthday Trust [1] showed a maternal mortality among the better fed women only one third that of the controls and an infant mortality, including stillbirths of only one-half

There is evidence that the diet of pregnant women should be quantitatively and qualitatively different from that of the non pregnant woman Quantitatively the diet is altered by a small but undoubt

[1] LADY (RHYS) WILLIAMS (1938) *Lancet* 1 204 This work has been extended and confirmation obtained of the result of the earlier cruder experiments (BALFOUR (1944) *Lancet* 1, 208) Moreover the experience of the war years 1939–45 has gone to show fairly conclusively that better feeding of pregnant women reduces both maternal and infant mortality The classes among which the maternal mortality was highest have been much better fed than previously having been granted cheap milk and priorities with other foods No country which values the coming generation can afford to drop such preferential treatment

edly significant increase in the intake of all foods [1] Thus in Great Britain where the income, less rent per head per week is over 15s the Calorie intake is on the average about 2500 Calories per day as against the 2100 for non pregnant women There is an increase in first class protein, calcium, iron, and presumably the vitamins as the social scale is ascended In no case however, do the average intakes of the calcium, phosphorus and iron reach the levels which experiment suggests are essential McCance and his colleagues estimate that the daily intakes should probably be of the following order Calories 2500, protein 90 grammes, calcium 1 5 grammes, phosphorus 2 grammes, iron 20 milligrammes In the well to do classes they found that the actual intakes were Calories 2500, protein 80 calcium 0 94, phosphorus 1 45 grammes total iron 14 4 milligrammes (inorganic iron 10 8 milligrammes)

Perhaps the best way of indicating the qualitative differences which should be aimed at is to give the recommendations of the Institute of Gynæcological Research (University of Pennsylvania) [2]

Non pregnant Women	Pregnant Women
1 pint of milk per day	2 pints of milk
1–2 servings of leafy vegetables	2–3 servings of leafy vegetables
2–3 other ,	2–3 other
1–2 fruit	3–4 (1 or 2 of citrus fruits)
3 slices bread	3 slices or more (whole grain pre ferred)
1 serving meat or fish	Meat or fish as ordered by phy sician
1 egg	1 egg
1–2 oz butter	1–2 oz butter
Vitamin concentrates as ordered by physician	Cod liver oil or vitamin A B_1 and D as ordered by physician

The comparison in proximal principles or nutrient "elements" works out somewhat as follows

Calories	2000–2600	2000–2600 for first three months 2400–3000 , second , , Decrease to 2000 or 2200 during the last three months if the gain in weight is abnormal
Protein	1 gramme per kilo body weight	1 gramme for the first three months then rising to 1 5 gramme
Calcium	0 55–0 68 gramme	1 0–2 0 grammes

[1] McCance Widdowson and Verdon Roe (1938) *Journ Hygiene*, 38

[2] Murphy and Bowes (1939) *Amer Journ of Obst and Gynæc* 37, 460

	Non-pregnant Women	Pregnant Women
Phosphorus	1 06-1 32	1 5-2 0 grammes
Iron	15 milligrammes	18-20 milligrammes
Vitamin A	6000	More
„ B_1	300	
„ C	300 (1 600)	
„ D	400	„

These recommendations are by no means impossible of achievement Several of the women investigated by McCance, Widdowson and Verdon Roe either achieved them or came near to them Significantly enough nearly everyone who did this belonged to the class with over 40s per week per head after making deduction for the rent—i e belonged to the wealthy or intellectual classes Such a diet is not cheap Because of the large amounts of vegetables consumed it takes time in preparation One criticism we make of the diet is that cheese is unrepresented It might well replace some of the milk, meat or fish Another is that the protein is too suddenly increased Increases of all foods should be gradual

Diet for lactation should follow the lines of diet in pregnancy, but the calcium should be increased

The estimates of the National Research Council of the U.S.A are as follows

Pregnancy (during the latter half) Calories 2500, proteins 85 grammes calcium 1 5 grammes iron 15 milligrammes, vitamin A 6000 I U thiamine 600 I U, riboflavine 2 5 milligrammes nicotinic acid 18 milligrammes ascorbic acid 100 milligrammes vitamin D 400-800 I U

Lactation The Calories are raised to 3000 the protein to 100 calcium to 2 grammes vitamin A to 8000 I U thiamine to 767 I U riboflavine to 3 0 milligrammes, nicotinic acid to 23 milligrammes ascorbic acid to 150 milligrammes while the iron and vitamin D are left at the pregnancy value

Diet for Different Climates and Seasons

The influence of climate and especially of a warm climate on the amount of food required is commonly exaggerated It seems natural to suppose that if the surrounding temperature is high, the amount of heat required to be produced in the body will be less But this is to lose sight of the fact that the temperature of the body is chiefly regulated by physical, and not by chemical means To put it more plainly we adjust the temperature of our bodies not so much by means of increasing or diminishing the amount of heat we produce as by the simple expedient of regulating the amount of heat lost i e by altering the amount of clothing and the ventilation of rooms

Heat and life, as has been already pointed out, are inseparable Whenever work is done, as when the heart beats, not all the energy obtained by oxidizing carbohydrate is utilized in doing that work Some—and it is an amount equal to two or three times that of the work done—has to be wasted Now thanks to the fact that we wear clothes our bodies live in an atmosphere of about 90° F — that is to say, in what is practically a tropical climate At this temperature the amount of heat produced in the body is in excess of that necessary to keep the body temperature at 37° C (roughly 98 6° F), even when that production is as small as is compatible with the full activity of our cells This means that, even in a temperature of 90°, we must constantly waste heat Suppose now, that one goes into the tropical regions As the external temperature rises the heat lost by the body because it is at a higher temperature than its surroundings becomes less and less Consequently there is still greater excess of heat to be got rid of One can adjust the balance either by eating less food, or by increasing the loss by wearing thinner clothes and increasing ventilation It is fairly clear that, supposing one's dietary is an average diet, it is a sounder policy to increase the loss of heat rather than to decrease its production by eating too little food In harmony with this one finds as a matter of fact, that the consumption of food by the inhabitants of the tropics is not notably less than that of those who live in the temperate zone We find too, that basal metabolism is but little altered in tropical countries For instance, Eijkmann found that the basal metabolism of Europeans living in Batavia was 40 Calories per square metre per hour [1] Others have reported a slight fall after some months residence As the basal metabolism falls but slightly if at all, a life involving much muscular effort in the tropics must entail the same intake of food as in temperate regions

This is not to say the intake of the *same* food as there are good reasons for a deliberate change of dietary régime to suit tropical conditions That people crave for different food or less food in hot weather or in the tropics is notorious Appetite fails and is stimulated by recourse to violent condiments and alcohol And it is here that considerations of physiology and dietetics may help in suggesting a diet for the tropics

First of all we know that in hot weather the bloodvessels of the skin are dilated to allow of greater loss of heat and therefore brain and alimentary tract are deprived of their normal supply Second there is a fall of arterial blood pressure of some 10 mm Hg possibly as the result of this vasodilatation in the skin Third if the temperature of the atmosphere rises to blood heat all the

[1] EIJKMANN (1921) *Jour d Physiol et d Path Gen*, 19, [illegible]

loss of heat must be due to evaporation of perspiration Fourth, protein foods and notoriously animal protein foods provoke a production of heat of no avail for muscular energy This heat has to be lost in surroundings hotter than the body and therefore by evaporation of perspiration Fifth the cooling power of the air depends on its percentage saturation with water vapour and its velocity so that if the air is near its saturation point and still it is very difficult to lose heat from the body

Putting all these facts together, we reach the conclusion that in hot climates the diet should be modified by greatly increasing the fluid intake to allow of profuse perspiration [1] by cutting down the intake of animal proteins which have a high specific dynamic action and replacing them by vegetable proteins which have a lower, by spreading the proteins over the different meals of the day to decrease the specific dynamic action and by using easily digested foods and avoiding those of high satiety value [2] To transfer the dietary habits of temperate regions to the tropics is to court disaster Much could be done by regulating the temperature of dwellings by refrigeration ventilation and air conditioning to render conditions of life more physiological What is true of the tropics is true also, but in a less degree, of summer conditions in a temperate climate

Suppose on the other hand, that one moves from a temperate to a *colder* latitude The body will now require more heat to keep its temperature up to the normal level and this is achieved by diminishing the heat lost, mainly by an increase of clothing If the external temperature falls still farther, however this method by itself becomes inadequate and steps must be taken to increase heat production it is only then that it becomes advisable to consume more food

"During the whole of our march says Sir John Franklin in describing his journeyings in the Arctic regions we experienced that no quantity of clothing could keep us warm while we fasted, but on those occasions on which we were enabled to go to bed with full stomachs we passed the night in a warm and comfortable manner Translated into physiological language this means that the demand for heat in the body was so great that it could no longer be met by diminishing loss but that the deficit had to be made up by an increase of heat production—i e by a greater consumption of

[1] Because of the loss of sodium chloride in the perspiration it is advisable that slightly salted water be drunk instead of plain water Deprivation of sodium chloride is known to lead to cramp of the muscles See also MORTON (1932) *Proc Roy Soc Med* 25, 1261

[2] Inquiry of dietary habits among the well to do in India shows that these suggestions are by no means adopted

food The blood supply to the skin is cut off to conserve body heat when there is too little food and a man feels cold Extra food enables the skin to have blood and the man feels warm [1]

What form the increased consumption of food takes is, comparatively speaking of little moment All that is really necessary is that the number of Calories which the diet is capable of yielding should be considerably raised As a matter of convenience however, and in order to avoid overfilling the stomach, it is best to have recourse to fat as the principal source of the extra heat required, for fat is the compactest form of fuel we possess [2] Carbohydrates would serve the purpose equally well so far as the cells of the body are concerned, but one would require to consume more than twice as much of them as of fat in order to obtain the same amount of heat Besides, in very cold latitudes carbohydrates are not so easily obtained as fat

The influence of *season* on the amount and quality of food required is similar in kind to the influence of climate though less in degree In summer, clothing should be diminished rather than food, in winter, warmer clothing should be worn

In hot weather the inclination is to eat less food and if this instinct is followed there will probably be a loss of weight If the normal winter diet be taken in disregard of the desire for food the body-weight is maintained, but health is apt to suffer The probability is that while the amount of food taken should yield approximately the same number of Calories, the nature of the food may as well be altered in the direction the appetite suggests Thus, hot beef-fat is repulsive in hot weather especially with the usual accompaniments to roast beef baked potatoes, and Yorkshire pudding, but cold beef with its fat intact served with a salad and a French salad dressing yielding just as many Calories, is appetizing Amounts of fat which would appear impossible to consume as hot mutton fat are quite palatable and digestible in the form of butter, cream, or ice cream

Probably too there should be less animal and more vegetable

[1] It is questionable if Scott's rations on his last expedition were adequate

[2] An interesting observation made by Stefansson is that each time on his return from the Arctic he was subject to digestive upset " When you have been for months on a diet of meat you almost always feel under the weather for two or three weeks after coming back to a mixed diet I imagine the reason to be that meat is such a bulky food that the stomach gets accustomed to large quantities Then when you eat the richer, civilized food and fill the stomach as much as you used to with meat you overload it —*The Friendly Arctic* 373 Macmillan & Co

protein consumed and the protein not concentrated into one meal as is too often the custom The specific dynamic action of protein should be avoided and the animal protein taken at a time when that action causes least trouble

A heavy meat meal at noon will be showing its specific dynamic action in the afternoon at about 3–4 p m —i e the time when the day is apt to be most oppressive Unless the nights are hot, meat at the evening meal is not amiss On the whole the general rule is that animal foods should be more sparingly consumed in summer, and the proportion of vegetable matter in the diet relatively increased The demand for hot foods and drinks in cold weather and cold foods and iced drinks in hot weather has more psychological than physiological or instinctive basis A litre (1¾ pints) of iced water will subtract but 37 Calories from the body and an equal quantity of a hot drink, swallowed at 45° C, will add but 8 Calories Such amounts are a bagatelle

Influence of Personal Peculiarity There is a widespread impression that some people can ' get on ' with less food than others even though they are living under identical external conditions There are those of whom it is said that their food does them no good while there are others who without eating much put on weight There is ample evidence of this from work already quoted that on the intakes of 63 men and 63 women [1] And there will be still more evidence when Miss Widdowson s observations on the food intakes of over 1000 children are published At any age there are children taking twice as much or more of some proximal principle of diet than others at that age Nor will the high or low intakes appear to be related to stature weight or health This observation has troubled the dietitian and is still troubling him

That there is a norm for weight corresponding to height and age is clear from the data of insurance companies and a marked departure from the norm (say over 10 per cent) is viewed with suspicion by their medical officers There is evidence from insurance statistics that it is better to be overweight than underweight in the twenties and underweight than overweight in the forties and later

The majority of people who do not have to trouble about their figure have an astonishing power of regulating their body weight For example as Du Bois has pointed out a man at 40 years of age may weigh exactly to within a pound or two what he weighed at 20 [2] The balance of intake and output has been adjusted in

[1] WIDDOWSON (1936) *Journ Hygiene* 36, 269 WIDDOWSON and McCANCE *ibid* 36, 294

[2] MARRACK (1942) *Food and Planning* reports the same of himself and one of us (V H M) can confirm the statement for his own body

his case over the twenty years to an error of less than 0 05 per cent Supposing that he were to lay down and not combust over that period 8 9 grammes of fat per day (the equivalent of a small pat of butter) he would double his weight in twenty years Some method of regulation of body-weight must prevent such an appalling catastrophe and the wonder is that so few people are obese

The mode of control is still obscure It is possible that body weight is regulated by appetite A well fed person is more energetic than one underfed and possibly consumes the extra food he has taken in the output of extra energy Moreover, the specific dynamic action of food rises if there is a surplus and the excess of combustible material is got rid of in this way On the other hand an underfed person restricts his activities and so adjusts his output to his intake If this underfeeding continues the food which is taken particularly the protein is utilized in the renovating of depleted tissues without evoking any loss due to specific dynamic action In the normal person there would be an increased appetite which, when sufficient food became available, would repair the losses due to previous under nutrition

We have to remember, too that there is an interplay of the endocrine glands Excess of thyroid activity leads to a lowering of the body-weight, defect of activity to an increase Defect of pituitary activity unbalanced by an increase of thyroid activity may lead to a gross deposition of fat Islets of Langerhans in the pancreas [1] and the cortex and medulla of the suprarenal also control metabolism, and the internal secretions of the gonads apparently influence it as well Some if not all, of these endocrine tissues are under the control of the central nervous system

As a working hypothesis we may assume that the regulation of intake and body weight is carried out by means of a complex mechanism in which appetite, specific dynamic action of food, the endocrine organs and the nervous system are all involved

If we accept bodily activity as an index of the irritability of the nervous system we can see why it is that some people need a greater intake of food than others In a series of observations reproduced in the Food (War) Committee s report the Caloric intakes of three boys one very active one active and one very quiet are shown A reference to Fig 12 will show that the very active boy at 15 years of age is taking double the amount which the very quiet

[1] The elderly diabetic is frequently overweight at the beginning of the disease and the young diabetic on insulin usually takes considerably less than 2500 Calories per day and yet maintains his weight for about forty years while the other (G G) eats considerably less in order to avoid gain of weight

boy takes and one and a half times that taken by the active boy The influence of the nervous make up of the boys considered is obvious

Pavlov considers from his study of conditioned reflexes in dogs that we can find the Hippocratic temperaments ' reflected in his animals and that in the large central group of well balanced temperaments there are to be seen the phlegmatic and the sanguine '[1] The one is quiet, self contained and sedate, the other lively and active If we translate these observations on dogs to man we can see how the lively ' sanguine ' temperaments will need more food to maintain body weight than the quiet ' phlegmatic temperaments In fact the explanation of the observation of the opening paragraph of this section lies probably in temperament or inherited constitution of the nervous system, coupled with the possibility that the differences in intake and output are due to differences of weight build shape of body and occupation The declining activity of body when middle age is reached probably accounts for the increase in weight commonly observed at that time The body has become accustomed to a large intake to support the demands of youth and is loath to give up its food habits although activity no longer demands such an intake Du Bois calculates that a decrease in activity comparable to walking 1½ miles per day might result in the deposition of nearly ⅓ oz of fat per day or 7 17 lb in a year

We may take it that individual make-up (nervous and endocrine) does explain idiosyncrasies of food intake This warns us of the dangers of dogmatism in matters of diet We can and may lay down rules as to the kind and amount of food required in different circumstances for the average person but we are treading on dangerous ground when we come to apply these rules to individual cases In the matter of diet every man must, in the last resort, be a law unto himself but he should draw up his dietetic code intelligently and apply it honestly, giving due heed to the warnings which Nature is sure to address to him should he at any time transgress

Psychology and Diet In the last paragraph a statement has been made which might open the way to every food fad from the days of Genesis to the present day It comes perilously near the motto of Theleme in Rabelais ' Fay ce que vouldras " or ' Do what thou wilt Although the subject has been lightly dealt with in the opening chapter it must be discussed again The problem is how far is dietetics a rational subject and how far the

[1] PAVLOV (1928) *Lectures on Conditioned Reflexes* 376 Martin Lawrence

private psychologies of individual people can upset, do upset and should be allowed to upset its principles That the origin of food habits is largely psychological has been pleaded at length by Renner—and also that it is rightly so [1] It is this view which must now be questioned

There are two definitely opposed schools of thought on this subject The one maintains that instinct is a guide [2] towards the

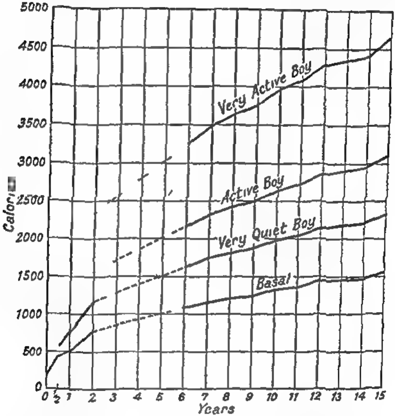

FIG 12—CALORIE INTAKE OF BOYS OF DIFFERENT ACTIVITIES

food needed The other school, on the contrary, believes that a man's choice of food is not governed by instinct but by his upbringing For convenience we may call the two schools the Lloyd and the Pavlov schools after their chief exponents The Lloyd school says that food which you like is beneficial to you Expanding the ambit of this thesis, it holds that choice of food is governed by instinct, and as instinct is fundamental, that such a choice is natural

[1] RENNER (1944) *The Origin of Food Habits* Faber & Faber, London

[2] Though surely not an infallible guide!

The Pavlov school insists that food habits are the result of conditioned reflexes That is we are born only with one food reflex i e of sucking milk and that all the other food reflexes are acquired and built upon this one simple innate reflex Consequently food habits are the result of upbringing the adult who likes and eats all foods being well educated and the one with violent likes and dislikes being badly educated Further corollaries are that such likes and dislikes are a bar to sound principles of dietetics and that the only conditioned reflexes a person should have towards food is those of eating it,[1] masticating it salivating on it swallowing it and digesting it The Lloyd school encourages food likes and dislikes the Pavlov school frowns on them

Now everyone would prefer the Lloydian school to be correct It supports one s natural (or unnatural) weakness for this, that and the other food or drink It makes one feel a fine fellow in insisting, say on pepper from a pepper mill rather than a caster or on a dry wine with the fish and meat courses and a sweet wine with the dessert or on the order of the courses of the modern international dinner[2] One feels that one is following the dictates of instinct and that one is in harmony with the great purposes of Nature

In favour of the Lloydian school there are sundry vague beliefs which rarely bear investigation plus it must be admitted, some sound observational work We are told that dogs eat grass to make themselves vomit when the alimentary tract is disturbed that deer and cattle walk miles to a salt lick and that ponies in the salt mines of Cheshire lick through the walls of their stables that animals deprived of adequate phosphorus in South Africa gnaw the bones of their dead comrades (and die of a form of botulism !) All these are observations on animals and have little to do with the case for in man with the dawn of reason it is contended that instinctual guidance declined and though animals *may* be guided by instinct in the choice of food (but see below) man is not necessarily so guided Besides the salt lick story and its supposed foundation on the need for sodium in cattle on a diet too rich in potassium, has been very shrewdly and justifiably criticized by Stefansson[3] The *Lamsiekte* of South African stockraisers can be explained by a euphoria produced by eating bones and the fact that horses and sheep in those parts of South Africa do not gnaw bones though lacking phosphorus hardly supports the instinctual guidance of the cattle

[1] Perhaps the person who maintains that all food is good but that some is better than another would be tolerated by the rationalist school of dietitians

[2] See *Food and the Family* Chapter 9 by one of us (V H M)

[3] STEFÁNSSON *Adventures in Diet*

Turning to human beings, it is said that the pica, i e desire, sudden and inexplicable, for unusual foods shown by pregnant and lactating women, that the passion for sugar evinced by children, that the loathing for tinned foods on the sides of Everest, are an evidence that instinct is taking a hand and guiding the human race to the right choice of food [1]. The characteristic of pica in human beings is its utter irrationality The passion for sugar in children is a passion for strong and lasting pleasant sensation and is by no means invariable and depends largely on upbringing Children who have not suffered under a Puritanical régime are not particularly keen on sugar—at least that is the fact with the children of one of us (V H M) The observation on mountain climbers are not germane Modern dietetics no longer frowns upon tinned goods Tinned foods are not ' bad for you, ' and avoidance of, or hatred for, tinned foods at high altitudes is not, therefore, an instinct towards dietetic sanity Besides, one result of low bloodsugar and want of oxygen at high altitudes is an irrationality and fickleness of desire Finally it is customary to quote that astonishing American experiment on allowing babies from 6 months onwards to 18 months to choose what they would to eat as evidence that what babies fancied did them good It did But the babies were allowed to choose *only* from protective foods Their choices followed no pattern nor order nor was there any invariable sequence followed, upon which could be based a scheme of dietetics for the toddler, let alone for older children and adults A baby might one day choose to eat four or five eggs only for its evening meal, at another time the choice might be liver followed by a pint of orange juice We simply *do not know* what their choices would have been if cream buns cakes, ice cream, fried fish and pickles had been on the menu The experiment merely tells us that if one s fancy roams among the protective foods one comes to no harm but, rather to good

The only sound experiments concerning man in support of the Lloydian hypothesis we have come across are those by Carlson on Vlcek the Bohemian laboratory assistant, who had a surgically made gastric fistula in consequence of a boyhood s mistake in drinking caustic soda with a resulting occlusion of the œsophagus Vlcek had a great liking for sweets desserts and so on with a dislike of acid or bitter foods In the course of experiments upon his gastric juice it would be found that when he had had a sweet course at the college caféteria which he particularly liked, the

[1] *As an aside is it not fair to say that in view of xerophthalmia beri beri pellagra scurvy rickets osteomalacia chlorosis and osteo porosis instinct has made a bad miss in guiding human beings to the target of sound diet?*

digestive capacity of the juice secreted was high If his lunch bored him it was low Similar observations were made by the Pennsylvania School of Medicine on medical students If the food were pleasant to eat served daintily and in pleasant surroundings 50 per cent of the students secreted more and stronger gastric juice than when food was indifferently cooked served on chipped china, on a newspaper for tablecloth in a dismally lighted cellar! (Curiously enough the other 50 per cent were not affected by surroundings)

Now clearly, unless a man is a hyperchlorhydric already, what he fancies is going to be digested better than what he does not fancy The evidence so far extends only to gastric secretion but it is probably true of pancreatic, biliary and intestinal secretion and therefore of total digestion and absorption Everybody must admit that foods which one fancies call out more and better digestive juices than things which one dislikes The moral however is not that one should eat only what one likes, but should like what one eats

Richter in his Harvey lectures published in 1943 sums up a series of experiments mainly upon rats which seem to show that they have an instinctive choice of the food which would benefit them Animals with a diet low in phosphorus make for one with a high content when given the choice [1] A whole series of experiments with definitely deficient diets were given and in every case the animals seemed to know when given the choice which food would be good for them In no case, however, except perhaps one to be mentioned later does Richter give an example which can be unhesitatingly accepted and cannot be explained on the grounds of a euphoria caused by eating the right thing We have mentioned, *en passant* [2] a series of illuminating experiments on the choice of foods by the laboratory rat If you run him out of B_1 and then give him a choice of foods with and without B_1 he will choose the food containing B_1 But if you flavour the B_1 containing food with cocoa and later transfer the cocoa to the food without B_1 he is fool enough to transfer his affections also He now eats a food which could do him no good Instinct has not told him where the B_1 lies *He fancies the food which contains no* B_1

Between foods which contain or do not contain vitamin A he shows no inerrancy of choice The explanation the experimenters

[1] This has not been the experience of other workers See McCollum Orent Keiles and Day (1939) *The Newer Knowledge of Nutrition* 161

[2] Harris, Clay Hargreaves and Ward (1933) *Proc Roy Soc B* 113, 31

give ■ as follows When an animal is "run out" of B_1 a chance choice of a food containing B_1 allows of recovery from symptoms within a few hours The animal feels *better as a consequence of* eating B_1 food He has a euphoria just as a man has after taking a glass of beer or a dose of morphia But the effects of vitamin A cannot be perceived so suddenly, consequently an animal cannot relate cause and effect and will eat food without vitamin A in it readily enough though his body is deficient in A Now it ■ quite likely that Richter s experiments can all be explained on the lines of producing a euphoria a well being of the animal which he associates with a particular food

There is one exception Experiments with children in Baltimore on giving them a chance of taking cod liver oil showed (unexpectedly, surely) that they availed themselves of the choice, but that later in the year they dropped taking it The assumption by Richter ■ that they needed vitamins A and D chose the food which contained those vitamins and then when their stores were adequate dropped it again Much more information is needed about the methods of carrying out this experiment the previous histories of the subjects *and the psychological surroundings of the experiment, before* it can be accepted ■ proving that instinct, or need, is a guide, an accurate guide, to what foods should be taken

Now the case for food habits being conditioned reflexes is based partly on Pavlov ■ observations on the alimentary conditioned reflexes of dogs and on observations of anthropologists such as Stefansson and Margaret Mead on the habits of races with whom they have come into contact *Pavlov and his colleagues* have shown that the mere lapse of time may act as a conditioning stimulus Animals accustomed to be fed every half hour salivate every half hour even if the food is withheld at that time The human being behaves in the same way, ■ ■ a patient treated for gastric ulcer by feeding every half hour with minced raw meat soon develops hunger contractions at half hourly periods People can train the large intestine to produce rush peristalses and a *defæcating reflex* at almost any chosen time in the day, so there is nothing sacrosanct about meal times

Puppies brought up by hand on milk have to be taught to obtain a conditioned reflex for meat eating This strange observation had been made by one of us (V H M) before coming across Pavlov s work Stefansson observed complete parallels with this in his sleigh dogs in the *Arctic Circle independently of Pavlov* Dogs, brought up on fish refused caribou or wild goose meat but could be trained to eat them by methods similar to Pavlov s mode of building conditioned reflex upon conditioned reflex One of us (V H M)

trained children to eat new foods by exactly similar means Finally, Pavlov showed that even the vomiting reflex in a dog could be evoked by such a stimulus as preparing the skin for the subcutaneous injection of morphine or apomorphine In man we see an exactly similar reflex Who having been sick after eating a certain food has not been nauseated by that food for a season after the incident, even for the rest of a lifetime ?

Scattered up and down in Stefánsson s writings are example after example of the Pavlovan conditioned reflexes in man and dogs although he could not have known of this work at the time We quote the following from Stefánsson s *Friendly Arctic* (1912)

A rule with no more exceptions than ordinary rules is that people like the sort of food to which they are accustomed An American will tell you that he can eat white bread every day but that he gets tired of rice if he eats it more than once or twice a month while a Chinaman may think that rice is an excellent food for every day but that wheat bread soon palls An Englishman will tell you that beef is the best meat in the world while in Iceland or in Tibet you will learn that beef is all right now and then but mutton is the only meat of which you never tire If a man is brought up on the west coast of Norway or on Prince Edward Island he thinks that herrings and potatoes make the best of all staple diets while an Iowa farmer likes potatoes well enough but would balk at the herring

Margaret Mead in *The American Character* (1944, Penguin Books) makes a similar statement about Hungarian children evacuated to the United States And we add to this the fact mentioned before that Bengalese used to rice, will starve to death during a rice famine rather than eat the wheat imported by a paternal Government [1] Examples of the conditioning of children to food reflexes will also be found in Renner s book already quoted

The apparent exceptions to the generalization that it is education and not instinct which determines food habits are that appetite seems to be some sort of a guide to caloric need and as already mentioned in the first chapter that the Akikuyu women eat more of the calcium containing foods than the men

It is difficult to admit that instinct plays much, if any part in determining the food habits of man and if this be so the need for early training to take a mixed diet with a large number of foods represented in that diet becomes paramount To day every country

[1] As this book was going to press a most important publication appeared containing confirmation of the views expressed above *M.R C Special Report Series* 254

because of their *vitamin C*, they *must* be considered mainly on the cost of that 'nutrient' The cheapest way of obtaining the vitamin is from raw cabbage salad, which, however, is not popular in this country For general purposes tomatoes, lemons and oranges are the cheapest ways of buying vitamin C, and the sooner we can regain the level of importation of citrus fruits of 1938–9 the better for the nation As the cost of vitamin C varies with the season the conscientious caterer must calculate from the tables and cost of foods the cost of a ration (30 milligrammes) of ascorbic acid

When strawberries are a shilling a pound it may be more economical to buy vitamin C as that fruit rather than as tomatoes or oranges The trouble is that few people are satisfied with the ounce or so of strawberries which give the day's ration!

The fat fish with the exception of salmon and sardines are among the cheapest foods we have for protective purposes (calcium phosphorus iodine, vitamins A and D), and for body building material For Calories they are medium in price but cheaper considerably than meat *At the controlled price of 7d per lb* herrings are a cheap food which no one except the rich can afford to omit from his food purchases

Speaking generally it is fair to say that the protective foods are not the dearest foods which we buy and the explanation usually given of their very general deficit in the diet of Great Britain—their costliness—is unfounded The *real reason* is *habit tradition*, and lack of an appreciation of dietetics

Second Economy in first class protein is best obtained by the use of cheddar style cheese herrings and herring roes At the respective prices of 1*s* 1*d*, 7*d* and 1*s* per lb these foods supply a day a ration of first class protein at 4*d* 3*d*, and 3*d* respectively Milk supplies it at 9*d*, the meats at prices ranging from 6*d* to 1*s* and the white fish at a price of from 8¾*d* (cod at 9*d* per lb) to 1*s* 6*d* (Dover Sole at 1*s* 10*d* per lb)

Third Economy in Calories is the easiest thing of all to practise for two reasons (i) the protective foods and protein foods combined do not often account for more than 30 per cent of the Calories of the diet (ii) the range of cost in Calories is enormous *It is one* hundredfold whereas the range of cost for first class protein rations is only from 3½*d* to 1*s* 6*d* or fivefold

There is little point in our setting forth the cost per thousand Calories of all the numerous foods that we eat because prices vary from time to time and place to place This does not mean that it is impossible in any one town at any one time to give an exact estimate of these costs or of the cost of a reasonable diet The report of the British Medical Association of 1933 upset that idea

for all time But a set of calculations based on either the West End stores prices in London or the cheap street markets prices would be useless for people living elsewhere, particularly those in the country Anyone interested in catering economically and dietetically must collect prices and calculate the cost per thousand Calories from them and from the various Food Tables in existence A general statement which will be true for all parts of the country is the following An economical dietary must be based upon cereals and cereal products, the pulses, dried fruit potatoes, butter margarine and suet milk fat fish, e g herrings sprats and mackerel cheese and bacon Moderate economy only can be found in the meats while lean fish and eggs are costly and to be considered luxuries Green vegetables and fruits from the Calorie point of view are also expensive, but as they supply some of the vitamins and the necessary salts they are essential, and small quantities despite their Calorie cost, must be included in the diet [1] For a fuller discussion of economy in diet the reader is referred to the book quoted or to *Sound Catering for Hard Times* [2]

[1] Emended from MOTTRAM (1938) *Food and the Family* 6th Edn Nisbet & Co

[2] MOTTRAM V H and MOTTRAM E C (1932) Nisbet & Co

PART TWO

THE NATURE OF FOODS

CHAPTER XII

FOODS TAKEN MAINLY FOR ENERGY PURPOSES

In this section of the book an attempt is made to give a survey of the foods eaten by people of European origin their characteristics and their value in diet As might be expected the first difficulty is classification Shall the foods be classified according to their chemical nature their biological origin or their function in dietetics? The problem has given many an organizer of conferences on food a headache For example if we follow chemical principles we separate the potato and the turnip both vegetables, if biological principles then marrows cucumbers and tomatoes are fruits and rhubarb is a "vegetable" Naturally the predilection of the authors is for a functional classification which again separates the potato from the turnip and leaves meat extracts in something like no man s land It is this functional classification which is adopted taking the classification[1] of the special joint committee of the combined food board of the United Nations and slightly rearranging some of its items and expanding it somewhat It is as follows

Group I	Oils and fats including butter and margarine sugars and syrups ; cereals potatoes pulses and nuts
Group II	Milk and milk products excluding butter, meat including cured and canned meat and meat extracts jellies etc poultry fish eggs
Group III	Fruit and fruit products vegetables leafy other vegetables including many "vegetable" fruits
Group IV	Beverages
Group V	Condiments

It will be seen that the first group consists of foods mainly taken for the production of Calories though butter, cereals and potatoes

[1] *Food Consumption Levels* (1944) H M Stationery Office

do supply vitamins as well, and the pulses and nuts supply protein The second group of foods is taken mainly for body building purposes though again all supply vitamins and the milk division mineral elements in addition Group Three supplies mainly vitamins and inorganic elements—their energy producing and body building powers being almost negligible

FOODS TAKEN MAINLY FOR THE PRODUCTION OF ENERGY

1 Oils and Fats, including Butter, Margarine and Cooking Oils

Before the war of 1939–45 it would have been natural to start this section with the cereals and starch and sugar containing foods, but it has been brought home to us how much we depend on the tropics and polar regions for our supplies of oil and fat Probably no deprivation during the war was felt so much as that of fat At a pinch we can grow half our cereals and sugar in Great Britain and increase our potato crop by 50 per cent, but we cannot produce fat at the same time This comes from tropical or subtropical regions—from palm fruit, palm kernel oil cotton seed oil and peanuts—or from whale oil mainly from the *Antarctic* The direction in which the dietary of even the poor and unemployed has moved in this country in the last 100 years is in the direction of obtaining more and more fat Once it was thought that 50 grammes of fat was sufficient per day for the poor Even in the 1931 slump the unemployed were consuming 100 grammes per day [1] Nor is this astonishing when it is realized that margarine at *5d* lb produces more Calories per *1d* than any other food *Fat per gramme gives two and a half times as many* Calories as a starchy or sugary food

Pride of place among the fat foods is taken by butter This is more because of the esteem in which it is *held by people than* because of its intrinsic food value though it must be admitted that at *1s 7d* per lb it is not a dear food It costs at that price *5½d* per 1000 Calories, and at the price to which it soared in the war of 1914–18 in Great Britain it cost but *8½d* per 1000 Calories Butter making is however not an economic proposition in this country and we shall probably continue to import butter from New Zealand and Australia and sell it here at a price which causes *astonishment and indignation in the Antipodes*

[1] CATHCART and MURRAY (1932) *Med Res Council Spec Rep* 165

Butter

Butter is produced from cream by churning This causes all the fat globules in the cream to run together into a solid mass, while the fluid part, containing almost all the sugar and most of the caseinogen, remains in the form of butter milk The flavour and aroma of butter are due to the growth of organisms in the cream during ripening The superior flavour of Devonshire and Cornish butter is due to the strains of lactic acid producing microbes found in the soured cream used in making butter These microbes when isolated in pure culture can be used to control the flavour of butter produced elsewhere or even to transfer these flavours to margarine Acetyl methylcarbinol and diacetyl are two of the substances manufactured by the microbes, for they are found in butter and have an odour reminiscent of butter, but by themselves are not entirely satisfactory in producing a butter flavour

The trace of caseinogen which remains in the butter is of importance for the decomposition which it undergoes on keeping is apt to make the butter turn rancid The presence of water in the butter facilitates this change Butter will *keep indefinitely* if it is dehydrated This method is largely used in India for the preservation of butter (ghee) and also on the Continent Commercial processes have been worked out in New Zealand for dehydrating butter for shipment to the forces in World War II, and will probably provide a convenient ' spread in tropical regions after the war Canada and other countries already put up canned butter for shipment abroad

The exact *amount of fat in butter* varies within limits but averages about 82 per cent, or twice as much as the amount in cream An ounce of butter therefore may be reckoned as the equivalent of $\frac{4}{5}$ oz of pure fat In addition butter contains 12 to 15 per cent of water and about 2 per cent of non fatty organic matter chiefly caseinogen and milk sugar It is rich in vitamin A [1] but poor in vitamin D

The most striking chemical characteristic of butter fat is its richness in those fatty acids (butyric, caproic, caprylic, and capric) which are soluble in water Of these it contains about 7 per cent Butyric acid indeed may be said to be the hall mark of butter, from which it derives its name The caprylic and capric acids apparently lower the need for vitamin B_1 Of the insoluble fatty acids present oleic is the most abundant Butter fat contains 40 per cent of olein This results in a low melting point (31-34° C)

[1] The figure given in *The Nutritive Value of Wartime Foods* q v is 1136 I U per oz but see above p 142

In old fashioned nurseries children were allowed to have butter or jam with their bread and never the two together To-day apparently most children get what they like There was never any real reason for the old rule except that of mortifying the flesh, for butter is an inexpensive source of energy

At the same time, it must be admitted that one pays for the pleasant flavour of butter As far as energy value is concerned, a pound of dripping is more than the equal of a pound of butter, and costs only half as much

We have here another example of the fact so often pointed out, that in buying foods we pay usually for the likings of the palate rather than for the needs of the body For those who can afford it, that may be quite justifiable, but for the poor the advantages of margarine and dripping as cheap sources of fat cannot be too strongly insisted upon The dripping has, however, only small traces of vitamins A and D and on that account should not be allowed to replace butter and vitaminized margarines in the diet of children

In addition to butter and margarine there are fats used in cooking or other preparation of food for the table which have been desperately missed during the war of 1939–45 These are *lard* and *bacon fat*, *suet*, *dripping frying fats* and *oil* Lard is used in pastry making and in shallow frying, suet in the making of suet puddings and mince meat, olive oil for deep fat frying and in salad dressings They all contain, with the exception of suet, nearly 100 per cent fat Thus the analyses are dripping 99 0 per cent fat, lard, 99 0 per cent, and olive and "edible oil," 99 9 per cent The conventional values of these would be approximately 4220 Calories per lb or 266 per oz The figure for suet as given by McCance and Widdowson is also 99 0 per cent fat, but this must have been for kidney suet with a very low percentage of connective tissue—it had but 0 9 per cent of protein and only a trace of water Older figures by American authorities range from as low as 71 per cent fat up to 94 It depends on the amount of connective tissue and the source of the suet, subcutaneous mesenteric or from around the kidneys [1]

In modern days it has become more and more the custom to buy suet already prepared Doubtless this will be so after the war for fewer people will have time to chop suet in the making of puddings and mincemeat These suets contain up to 16 per cent

[1] The *Atwater and Bryant* figures run from 70 7–94 3 per cent, beef suet according to Plummer has [illegible] 3 per cent fat mutton suet 96 6 The Rowett figure is 93 3 Chatfield and Adams for kidney suet give [illegible] 0 per cent for a thin carcase, [illegible] 0 for a medium and 94 0 for a fat

of rice starch to prevent the flakes of suet from running together again This of course, alters the Calorie value markedly One lb of 100 per cent fat should yield approximately 4220 Calories (266 per oz) 99 per cent fat yields 4180 Calories (260 per oz) while a suet of 16 per cent rice starch 83 per cent fat and 1 per cent water would yield approximately 3800 Calories (237 per oz) In view of the small amounts of suet in a helping of suet pudding or in a mince tart this may seem a small point but it is a point worth making

There are too, commercial frying fats and oils on the market These are hardened or semi hardened vegetable and animal oils—quite useful commodities and having the same Calorie value as olive oil. Doubtless they will increase in consumption on account of their cheapness when compared with olive oil, but the connoisseur will always look askance at them because of their chemical laboratory odour It is said however, that arachis oil (peanut oil) makes a satisfactory substitute for olive oil in salad dressings The proportion of the Calories obtainable from a salad depends almost entirely on the amount of the oil in the dressing even when potatoes are an ingredient

We must not overlook the important contribution which fat meats and cheeses make to the Calorie intakes of people although meat and cheese are more reasonably considered among the foods which are taken for their protein content Fat bacon may have up to 74 per cent fat with a Calorie value per lb of approximately 3100 Calories per lb (193 per oz) Streaky bacon has 45 per cent fat with a Calorie value of 2420 (150 per oz) A mutton chop has 48 per cent fat and Calorie value of 2140 (133 per oz) Cheese, such as Cheddar, contains 34 5 per cent of fat and has a Calorie value per lb of 1860 (116 per oz) If nuts formed any large part of the diet they too would be important as sources of Calories according to their percentage content of fat

The amount of fat in food largely determines the amount of the sense of satisfaction we feel at the end of a meal and also of the lasting effects' of that meal One reason is that fats are so calorigenous and that is why in a great war most of us hunger for them

2 Sugars and Syrups

The importance of sugar as a modern food commodity cannot be over-emphasized Originally a highly priced condiment it has become with the discovery of cheap ways of production and manufacture so important a source of Calories that dietitians are beginning to ask whether there be not great danger in eating sugar in

the *quantities we do* The average consumption in the Unite Kingdom in the years 1935–39 was about 95 lb per person pe year [1] or 4 17 oz per day yielding 467 Calories—i e about 15 pe cent of the daily Calorie needs Consumption in the Unite States was still higher and reached a peak of 112 lb per person pe year in 1941 Other countries may take much less the Russians, fo example, taking less than a quarter of what we take in Great Britain

The reasons for the disfavour in which sugar is held are (i) A usually taken, it is a source of Calories only, and therefore if th appetite be sated on it foods containing proteins, mineral element and vitamins are crowded out of the diet (ii) It is held by America dentists to account for caries of the teeth—an old story neithe proved nor disproved as yet (iii) It may conceivably lead to th development of diabetes This also has been neither proved no disproved, but it is possible that the sudden flooding of the blood with glucose throws a strain upon the insulin producing cells of the islet tissue of the pancreas Diabetes has increased in the United States somewhat as the consumption of sugar has increased but this is no proof that the two are causally connected For the present it is absurd to interdict sugar consumption, but it is wise to be on the watch for possible dangers The "food reformers" fancy that it is an "unnatural" food to be avoided unless eaten in a raw and unrefined state, we may dismiss this as illogical unscientific and absurd

We have spoken as if "sugar," i e sucrose or saccharose, the disaccharide occurring in the sugar-cane and the sugar beet, were the only sugar in question in the diet So for practical purposes it is, but different varieties of sugar enter into the composition of articles of diet, and they may be divided into two groups (1) the disaccharides ($C_{12}H_{22}O_{11}$), the chief examples of which are cane, beet, or maple sugar (sucrose or saccharose), malt sugar (maltose) and milk sugar (lactose), [2] (2) the monosaccharides ($C_6H_{12}O_6$) exemplified by grape sugar (glucose or dextrose) fruit-sugar (fructose or *lævulose*), and invert sugar, which is a mixture of these two and is best known in the form of honey

We may now consider each of these varieties in some detail

1 Disaccharides Cane sugar or sucrose *is the most familiar* of all kinds of sugar It is commonly derived from certain special grasses such as the sugar cane or sorghum, but occurs also in

[1] *Food Consumption Levels* (1944) H M Stationery Office

[2] There are other sugars occurring in foods (e g *trehalose* a disaccharide in edible fungi raffinose a trisaccharide from beet molasses, and pentose a five-carbon sugar in many ripe fruits) but these are of no dietetic importance

maller amount in a great many plants and fruits When erived from other sources than the sugar cane special names, uch as beet sugar or maple sugar are usually given to it but it nust be distinctly understood that these are chemically indis inguishable from the form of sugar derived from the sugar cane

Cane sugar has been in use in the world as a food for many ages, but it is only within comparatively recent times that it has been manufactured cheaply enough to take an important place in ordinary diets The following brief history of its introduction into Europe is taken from a pamphlet on *Sugar as Food*, issued by the United States Department of Agriculture [1]

' Sugar from the sugar cane was probably known in China 2000 years before it was used in Europe When merchants began to trade in the Indies it was brought westward with spices and per fumes and other rare and costly merchandise and it was used for a long time exclusively in the preparation of medicines An old saying to express the loss of something very essential was, Like an apothecary without sugar' Greek physicians several centuries before the Christian era speak of sugar under the name of 'Indian salt It was called honey made from reeds, and said to be like gum white and brittle But not until the Middle Ages did Euro peans have any clear idea of its origin It was confounded with manna or was thought to exude from the stem of a plant, where it dried into a kind of gum When in the fourteenth or fifteenth century the sugar cane from India was cultivated in Northern Africa the use of sugar greatly increased and as its culture was extended to the newly discovered Canary Islands and later to the West Indies and Brazil it became a common article of food among the well to do In 1598 Hentzer a German traveller ascribed Queen Elizabeth s blackness of teeth to her great use of sugar By many the new food was still regarded with suspicion It was said to be very heating, to be bad for the lungs and even to cause apoplexy Honey was thought to be more wholesome because more natural than the 'products of forced invention' "

One of the earliest records of the use of sugar in this country [2] is to be found in the accounts of the Chamberlain of Scotland in the year 1319 Its price at that time was 1*s* 9½*d* per pound = £2 11*s* 6*d* at the value of money in 1939

The ***composition of the sugar cane*** and its juice is about as follows [3]

[1] Farmers Bull (1913) No 535

[2] See BANNISTER Cantor Lectures 1890

[3] WINTON and WINTON (1939) *Structure and Composition of Foods*

COMPOSITION OF SUGAR CANE AND JUICE

	Stalks	Juice
Water	74 96	85 00
Protein	0 58	0 10
Fat and wax	0 38	nil
Sugars	13 40	13 70
Cellulose, Lignin, Pentosans	10 04	0 65
Ash	0 64	0 45

In order to separate the sugar, the canes are crushed, and th juice expressed by means of heavy rollers This juice is the clarified by the addition of lime and heating to 94° C Othe clarifiers are basic aluminium carbonate, silicic acid with calcium silicate and sodium aluminate The clear fluid is readily separated from scum and mud and is then concentrated by boiling *in vacuo* to a water content of 45 per cent The crystals which form are centrifuged from the mother liquor This crude sugar is known as *muscavado* and is shipped to the refineries It contains from 94 to 98 per cent of sucrose At the refineries it is still further clarified and finally decolorized by filtration through bone char coal The final product of crystallization is white and is 99 50 per cent pure sucrose If loaf sugar is wanted it is run into moulds Moulded cube sugar is made in the form of sticks, and afterwards cut into cubes by machinery Granulated sugars are made in the centrifuge Other varieties depend on the mode of crystallization and grinding

Beet-sugar Fully two thirds of the cane ' sugar commonly used is really derived from the sugar beet The following account of the growth of the industry is from the pamphlet already men tioned [1]

'Marggraf, a chemist of Berlin, first discovered in 1747 that beets with other fleshy roots, contained crystallizable sugar identical with that of the sugar cane In 1796 Marggraf s pupil, Achard, erected the first manufactory for beet sugar and in 1799 he brought the subject before the French Academy He manufactured beet sugar on his farm in Silesia and presented loaves of refined beet-sugar to Frederick William III of Prussia in 1797 but the 2 to 3 per cent of sugar that could be extracted by the methods then in use was too small for commercial success A new stimulus was given by the sugar bounties of Napoleon in 1806, and methods were rapidly improved especially in France Two great difficulties were still to be met the percentage of sugar present in the beet was

[1] U S Dept of Agr (1913) Farmers Bull No 535

small (6 per cent) and it was separated with great difficulty from the many non sugar constituents, some of them acrid and of very unpleasant taste Science now came to the rescue, and a beet was gradually developed having a larger percentage of sugar and a smaller percentage of the undesirable impurities Barber says that in 1836 18 tons of beetroot were necessary to produce 1 ton of sugar, in 1850 this quantity was reduced to 13 8 in 1860 to 12 7 tons and in 1889 to 9 25 tons From 6 per cent of sugar as found by Marggraf the sugar beet of good quality now contains 15 per cent and more [illegible] per cent being considered necessary for profitable manufacture'

The sugar is extracted from the beets by rasping them to a pulp, extracting and evaporating *in vacuo* with subsequent decoloration by means of animal charcoal

To the ordinary consumer beet sugar is not distinguishable from that derived from the sugar cane and it has already been stated that to the chemist the two are really identical There is no evidence for the statement sometimes made, that beet sugar is more injurious to health than genuine cane sugar

Maple sugar is derived from the sugar maple of North America by tapping the bark in early spring and allowing the sap to escape as it flows upward The sap is evaporated and the sugar allowed to crystallize out while the residue is used as maple-syrup One maple tree yields about 4 lb of sugar in a season

There is no chemical difference between the sucrose of maple sugar and that derived from the cane or beet but it is mixed with ethereal substances and organic acids which give it a peculiar flavour It is probably on the presence of these that the slightly laxative qualities of maple sugar depend As a commercial source of sugar the maple cannot compare with either the cane or the beet and maple sugar is now chiefly used as a luxury and for the sake of its agreeable taste

The average composition of these sugars in their raw state is as follows

COMPOSITION OF SUGARS

Source	Water	Cane sugar	Invert Sugars	Ash
Sugar-cane	0 91	96 68	1 01	0 59
Sugar beet	[illegible] 42	89 60	5 47	—
Maple	3 70	86 48	8 76	1 06

After being subjected to the process of refining sugar is practically a pure chemical substance There is some demand for the cruder Barbados sugar both for confectionery and for the food faddist

Some types (e g 'pieces) have a pleasant flavour, but ferment easily and sometimes include livestock Raw sugar contains appreciable amounts (0 159 per cent) of cane fibre, dirt, scale and lime salts [1]

The study of lactose and maltose are best postponed till we deal with milk and malt

Certain substances derived from cane sugar deserve brief mention When strongly heated sugar melts into a yellowish liquid and undergoes some physical alteration, so that on cooling it does not crystallize, but forms a transparent, brittle mass familiar to everyone as ***barley sugar*** If heated to a still higher temperature its colour darkens, and it acquires a bitter taste, the product being ***caramel*** which is so largely used in cooking operations

Treacle, molasses and ***golden syrup*** are produced as by products in the manufacture of crystallized sugar Their syrupy consistence is in part due to the fact that the other substances which they contain prevent the cane sugar from crystallizing and partly also to their being fairly rich in fruit sugar The following represents their composition

	Louisianan [1] Molasses	Treacle [2]	Golden Syrup
Cane sugar	47 85	32 5	[illegible] 6
Glucose and fructose	23 08	37 2	47 4 [3]
Extractive and colouring matter	—	3 5	1 2
Inorganic substances	7 58	3 4	1 3
Water	18 20	23 4	16 4

One pound of Lyle s Golden Syrup yields 1508 Calories (94 per oz) and contains 13 oz of mixed sugars equivalent on digestion to more than 13 oz of glucose Treacle is an excellent source of iron and calcium in the diet

2 *Monosaccharides* The other great group of sugars is the monosaccharides The best example of these is ***glucose*** which occurs so abundantly in the grape When grapes are dried to form raisins the glucose separates out and may be recognized in the raisins in the form of little yellowish white granular masses Commercial glucose is usually got by boiling starch with acids It occurs in a syrupy form When heated it turns brown and is used in cookery as sugar colouring ' Mixed with egg albumin it is largely employed in the preparation of icing and ' *fondants* in confectionery and in the manufacture of bonbons

[1] WINTON and WINTON *op cit*

[2] From earlier edition

[3] Glucose 24 4 and fructose 23 0 per cent

Fruit-sugar or fructose is found, as its name implies, in most fruits. It is with difficulty crystallizable and is hardly ever met with in an isolated form in dietetics.

Invert sugar is a mixture of glucose and fructose. It can be prepared from cane sugar by the action of ferments or by simple boiling, but more readily by boiling with acids. Thus "inversion" of cane sugar, as it is called, goes on rapidly when cane sugar is boiled with fruit juice, the active agent being the acid of the fruit. Thus a considerable proportion of the cane sugar used in making jam is converted into invert sugar in the process. It is important to remember that invert sugar does not readily crystallize.

Honey is the most familiar form of invert sugar. It contains about equal parts of glucose and fructose, its flavour being due to the presence of small amounts of volatile substances derived from the flowers. The mean composition of pure honey was found by Browne [1] to be as follows:

Composition of Honey

Moisture	17 70 per cent
Invert sugar	74 98
Sucrose	1 90
Dextrin	1 51
Ash	0 18

McCance and Widdowson give the composition of English honey as: Protein 0 4 per cent, fat, a trace, available carbohydrate 76 4, no starch or dextrin, and producing 288 Calories per 100 grammes or approximately 1320 Calories per lb (82 per oz.). Honey in the comb has 4 6 per cent of wax and its Calorie value is 281 Calories per 100 grammes.

The comb consists of waxy substances which are probably incapable of digestion.

The basis of *sweetmeats* is either cane sugar or glucose. Sugar candy is one of the purest. It consists of cane sugar which has been allowed to crystallize round threads and consists of almost pure sucrose.

Toffee consists of melted sugar and butter in various proportions. The home made toffee of McCance and Widdowson contains 1 oz. butter to 8 oz. sugar and 5 oz. golden syrup. Its composition is 0 2 per cent protein, 6 2 fat, 90 8 available carbohydrate and yields practically 400 Calories per 100 grammes or 1820 Calories per lb (113 per oz.).

Chocolate contains about 45 per cent. of cane sugar, but no

[1] Quoted by Winton and Winton, *op. cit.*

glucose or fructose. The rest of it is composed of cocoa powder (For analyses see pp 479, 480 and 483)

A mixture of glucose or invert sugar and cane sugar is used in the preparation of uncrystallized sweets such as the creamy matter in the interior of chocolates

The colouring of sweets is derived either from burnt sugar or from one of the aniline dyes most commonly eosin Cochineal is also a favourite colourer It is interesting to note that aniline dyes may be excreted in the urine almost unchanged and cases are on record where patients have been supposed to be passing blood, when they had merely been sucking red sweets There is no reason to suppose however, that such substances are in any way harmful

Jams consist essentially of fruit preserved in a *strong solution* of sugar We have already seen that the acids of the fruit aided by the high temperature employed in the course of preparation bring about the conversion of a considerable proportion of the cane sugar into the invert form Home made jam is usually boiled for a longer time than the commercial article, and consequently contains more invert and less cane sugar than the latter Aitchison Robertson[1] gave the proportion of cane sugar in most home made jams as *20 per cent*, while commercial jams have *anything from 10 to 50 per cent* *In some home made jams* which he examined the proportion of cane sugar which had been inverted was as follows

	Proportion of Cane sugar inverted
Strawberry	two fifths
Raspberry	three fifths
Blackberry	four fifths
Marmalade	five-sixths
Plum	*six sevenths*

The importance of these figures is derived from the fact that the larger the proportion of cane sugar which has been inverted the less likely is the jam to interfere with digestion (see p 230)

Commercial glucose does not crystallize and so is often used to make jam from inferior fruit or from the remains of fruit, the juice of which has been used to make fruit syrups and jellies Such jam may have a good appearance but is deficient in fruit flavour It is however quite wholesome and nutritious

The "setting of jellies is due to the presence of pectin in the fruit (p 21) If boiled *too long* the power of gelatinizing is lost

1 The Value of Saccharine Foods as Articles of Diet (1898) *Scottish Medical and Surgical Journal* 3 30

and a syrup results instead of a jelly In commercial jams and jellies pectin is sometimes added to prevent this There is a preparation on the market of pectin which is used in making home made jams set

More than half the weight of any given quantity of jam is made up of sugar in some form or another The nutritive value of jam resides almost entirely in its sugar content its Calorie value being 1160 per lb (72 per oz)

Digestion of Sugar

The first factor which determines the digestibility of a sugar is its chemical form No matter in what form sugar is consumed in the food it can only be assimilated as a monosaccharide (glucose, fructose or galactose) Hence we find that provision is made in the alimentary canal for the conversion by means of suitable ferments, of all forms of disaccharides into glucose fructose and galactose i e they are hydrolysed It is evident, then, that from a dietetic point of view we may speak of the disaccharides as undigested and the monosaccharides as predigested sugars It now becomes clear why sweet fruits are such important dietetic sources of sugar It is because they contain the latter in a form in which it is fit for direct absorption into the blood For the same reason honey must be regarded as a very easily digested saccharine substance and the importance of the inversion which cane sugar undergoes in the manufacture of jams also becomes manifest The superiority of home made over commercial jams is also set in a clearer light by reference to these considerations

The second factor which influences the digestibility of a sugar is the degree of concentration of its solution In strong solution sugar is an irritant to the tissues In contact with the skin it is apt to set up superficial inflammation This is familiar in the form of the eczema which is apt to appear in diabetics from the contact of the sugar containing urine with the skin and from the similar condition occurring on the arms of grocers and other persons who have frequently to handle sugar and it is on account of its irritating properties that sugar cannot be used as a subcutaneous aliment, though otherwise well adapted to fulfil that function All attempts to use it in that fashion have been frustrated by the pain which it sets up The same is true of the stomach Brandl experimenting on dogs found that a 5 7 per cent solution of sugar produced reddening of the mucous membrane if the concentration was increased to 10 per cent the mucous membrane became dark red while a 20 per cent solution produced pain and great distress This irritating effect on the mucous membrane is accompanied by the production of much mucus and the pouring out of a highly

acid gastric juice Enemata must not contain more than 4 to 5 per cent of glucose These irritating effects seem to be much more pronounced in the case of cane sugar than in that of the hexoses

As used in ordinary diet cane sugar depresses the acidity of the gastric juice and delays evacuation of the stomach[1] A hyper chlorhydric person can take sweets between meals with impunity but a hypochlorhydric cannot It would be interesting to discover whether the sugar added to the fruit or the cereal course at break fast delays evacuation of the stomach or not When sucrose enters the duodenum it is so rapidly inverted and absorbed that for administration by mouth for therapeutic purposes glucose has few advantages over ordinary cane sugar[2]

But all disaccharides must be digested to monosaccharides before they can be of use to the body Lactose and cane sugar if they get into the bloodstream are excreted quantitatively by the kidneys unchanged Nor can the body deal with pentoses if they enter the system They too are excreted unchanged and a pentosuria results from the free consumption of fruits

The last point connected with the influence of sugar on the digestive organs is its supposed *injurious effects on the teeth* The im pression that sugar eating is bad for the teeth is so widespread that one can hardly suppose it to be devoid of all real basis It must be admitted however, that the supposition is not supported by any very conclusive observations If sugar does destroy the teeth, it probably does so indirectly by lingering in the crevices of the mouth, and leading to the production of acids which eat away the enamel though as far as we know no one has yet proved that *B acidophilus* can produce a sufficiently high hydrogen ion concentration to attack the enamel[3]

Assimilation of Sugars

The fate of sugar after entering the blood is to be converted into glycogen and stored by the liver and muscles as glycogen Now it has been found by the physiological experiment of injection into the bloodstream that not all sugars are capable of being directly converted into glycogen

It is considered that fructose is directly converted in the liver but that glucose passes to the muscles first and is converted there As the kidney threshold value is lower for fructose than glucose the sugar tolerance for fructose is less than that of glucose Most

[1] MILLER BERGEIM REHFUSS and HAWK (1920) *Amer Journ Physiol* 53 65

[2] *Lancet* (1935) 1 444

[3] See W H A WALLACE The Place of Sugar in the National Diet (1935) *Public Health* Dec 84–9

people secrete fructose in the urine if they take more than 50 grammes on an empty stomach. The tolerance for glucose is much higher, and 100 or, in exceptional circumstances 200 grammes can be taken on an empty stomach without causing glycosuria

It must further be borne in mind that the assimilation limit is not the same for all individuals Some people are better able to convert sugar into glycogen or have a higher threshold than others, and most people can take 50–100 or 200 grammes of glucose without passing sugar in the urine. If glycosuria occurs it is either due to the blood sugar being raised above the normal limits (i e the patient has diabetes mellitus which may be mild or severe) or the threshold of the kidney is lowered and glycosuria occurs although the blood sugar is within normal limits

Notwithstanding all this it must be noted that if sugar is taken along with other food and distributed uniformly over the day, very large quantities can be consumed without the danger of exceeding the assimilation limit Vaughan Harley was able to take a pound of cane sugar daily—with injurious results as regards his digestion it is true but without producing glycosuria As a general rule one may assume that 4 oz can be taken daily without any bad results but the exact amount must of necessity depend to a large extent on the muscular activity of the subject

Nutritive Value and Economy of Sugar

We have seen that refined sugar is to be regarded as a practically pure carbohydrate That being so its food value must be high, for *every gramme of it will yield 3 95 Calories of energy*[1] *An ordinary* lump of loaf sugar weighs about 5 grammes and yields therefore nearly 20 Calories. Five such lumps contain as much carbohydrate as a 5 oz potato It is evident from these considerations that even the amount of sugar ordinarily added to a cup of tea may contribute in no small degree to the supply of energy required by the body daily A pound of butter will yield about twice as much energy as a similar weight of sugar but at nearly four times the cost for sugar is one of the cheapest fuel foods Even at 4½d per lb it produces Calories at 2½d per 1000 or about the same cost as bread

It is *as a muscle food* however that sugar is of special importance We have already learnt that the carbohydrates are probably the chief source of muscular energy, and the sugars on account of

[1] It has been calculated that a single caramel or a pennyworth of candy yields sufficient Calories to provide the extra energy required in walking a mile (see C G and F B BENEDICT The Energy Content of Extra Foods (1919) *Boston Med and Surg Journ*, October 2 415)

the ease and rapidity of their absorption are better calculated to fulfil this function than any other member of the carbohydrate group For mention of its use in training see p 259 and for early evidence of its value previous editions of this work It is extremely useful also in rapidly raising the level of "sugar" in the blood when for any reason, e g fasting severe fatigue or an overdose of insulin, it has fallen to a low point

3 *Cereals*

Man, like every other animal, has always had to ' live off the land " *using the term in Stefansson s sense to* include water and air That is, he has to convert their products to his own purposes in providing food In this he has *gone through three stages*

First he has hunted and lived on the products of his bow, spear and fishing line—a most precarious way of living, still practised by races in a land where settled agriculture is impossible It produces a diet consisting mainly of protein and fat with very little carbohydrate The Eskimos are perhaps the best example to day of such early methods of ' living off the land ' No land so exploited can sustain a dense population The method is un economical and unplanned

The second stage is the nomadic, in which man has domesticated some animals and looked to an ordered control of their fertility for a supply of meat and milk This method obtained in early biblical times and to day the Masai are a good example of survival of this mode of living off the land It too produced a diet consisting mainly of protein and fat but with rather more carbo hydrate

The third stage is a stable agriculture, based upon the cultivation of cereals, wind pollinated grasses mainly, which grow in close association one with another and can be easily brought under control This type of agriculture produces a diet which is mainly carbohydrate with much less fat and protein It ties too, the agriculturist to the soil Nomadic life becomes impossible Such agriculture beginning in the alluvial soil along the river valleys of Mesopotamia and Egypt many thousands of years ago has now spread to every tropical subtropical and temperate land and cereals can now actually be raised within the Arctic Circle The type of cereal is naturally not everywhere the same It is wheat in the drier subtropical and temperate lands of Europe North America the Argentine Australia and India In more humid and hotter parts of the world it is rice, and where as in northern Germany, northern Russia and Scandinavia wheat does not ripen well rye takes its place The same is true of Scotland

but there oats take the place of rye, though at one time rye was very commonly grown in Great Britain A new cereal, maize, invaded the Old World from the New, and has thoroughly established itself round the Mediterranean in Roumania and Egypt and in South Africa Barley is a crop which can be grown on poor soils and as it ripens early, it once was a staple cereal in human diet in the northern parts of England It is to day used more for fodder and the manufacture of malt Millet and buckwheat though not strictly cereals have a similar mode of cultivation and millet forms the staple diet in parts of Africa and China

The success of cereal agriculture is due to the fact that land can produce about five times as much food as when given over to dairy produce More bulk of food is available and a greater density of population assured Moreover the population though dense is tied to the soil Civilization as we understand it depends upon density of population and tradition Without cereals density of population is impossible The handing down of tradition is easier in a static population than in a nomadic There can be no real civilization apart from cereal agriculture [1]

Now cereals by themselves are poor foods especially for human beings with alimentary tracts which cannot cope with bran and with phytates Their proteins are not so valuable in human nutrition as those of milk eggs cheese fish and meat They have less lysine methionine and tryptophane in their constitution and much more glutamic acid moreover often the percentage of protein is low in cereals especially when cooked as cooked they must be Their content of calcium is low their ratio of calcium to phosphorus very low what calcium there is is unavailable their iron though high is also unavailable to man It is true that their content of vitamin B_1 thiamine is high and they have moderate quantities of nicotinic acid and riboflavine but with the exception of vitamin E they have but negligible quantities of the other vitamins

They are therefore poor foods and wherever they form a high percentage of the diet—say over 60 per cent —the growth of their eaters is stunted and the physique poor They make for faulty bones and teeth for anæmia and avitaminoses A C and D This fact cannot be over emphasized the value of cereals in diet is that they are a *cheap source of Calories* It is almost their only value

Wheat is the aristocrat among the cereals both for dietetic and technical reasons and where *other* cereals form the staple food of

[1] The ancient civilization of Peru seems to have been based on the potato

the diet it would be well to displace them by wheat On the other hand the reduction of the consumption of wheat in this country by about 13 per cent in the years 1900 to 1939 and its replacement by foods such as milk, cheese and so forth is to be welcomed by the dietitian Naturally, during the war of 1939–45 there has been a great increase in Great Britain s consumption of wheat and other cereal products—about 20 per cent at the maximum—and it is to be hoped that in the years to come this will be diminished

Wheat

If a grain of wheat is cut into thin sections and examined under a microscope it will be found to consist of the following parts (Fig 13)

1 The *germ*, or embryo This is simply the young plant It represents about 1½ per cent of the whole grain

2 The kernel, or *endosperm* This consists of two large masses of nutritive material for the use of the embryo It makes up 85 per cent of the grain

3 The *bran*—an outer envelope mainly composed of "cellulose" impregnated with mineral matter and designed as a protective covering to the grain of which it makes up about 13½ per cent

4 The *scutellum*—a membranous tissue between the germ and the endosperm interesting in that it contains a large amount of vitamin B_1 (thiamine)

The chemical composition of the whole grain and of its three components is shown in the table on page 303 constructed from *The Nutritive Values of War time Foods* It will be noticed that the germ is characterized by its richness in protein and fat the endosperm by an abundance of starch and the bran by a preponderance of mineral elements and cellulose It should be added that the germ is further peculiar in that both its protein and its carbohydrate are chiefly present in a soluble form and it has a high amount of vitamin B_1 (thiamine)

If the section of wheat is more highly magnified, the structure of its various components can be made out in greater detail One can then see (Fig 14) that the *endosperm* consists of a delicate honeycomb of cellulose the cavities of which are full of starch grains the interstices being filled up by smaller particles consisting of a protein or mixture of proteins called gluten The gluten granules are most abundant in the outer zones of the endosperm

The relative proportions of starch and gluten differ in different kinds of wheat Generally speaking, it may be said that those

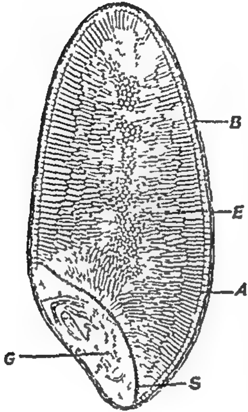

FIG 13.—DIAGRAM OF LONGITUDINAL SECTION THROUGH A GRAIN OF WHEAT

A Aleurone layer of cells forming outermost layer of the endosperm.
B Pericarp forming the branny envelope
E Parenchymatous cells of the endosperm.
G Embryo or germ.
S Scutellum

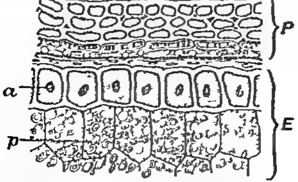

FIG 14.—CROSS SECTION THROUGH THE BRANNY ENVELOPE AND THE OUTER PORTION OF THE ENDOSPERM

COMPOSITION OF THE DIFFERENT PARTS OF A WHEAT GRAIN
(100 grammes contain)

	Bran	Endo sperm	Germ	Whole Grain English	Whole Grain Manitoba
Water (g)	8	13	8	13	13
Protein (g)	10 9	13 1	32 0	9 1	13 9
Fat (g)	4 2	1 2	7 7	2 3	2 6
Carbohydrate (g)	54 5	71 6	37 8	68 1	64 3
Calcium (mg)	98	13	58	36	28
Iron (mg)	12 9	1 8	9 7	3 1	3 9
Vitamin A (I U)	0	0	—	0	0
B_1 (μg)	—	69	2100	294	363
C (mg)	0	0	0	0	0
The figures for cellulose taken from an earlier edition of this book are					
	18 0	0 7	1 8	5 7	1 7

grains which look hard, translucent, and horny on section are rich in gluten and poor in starch, while for the grains which are soft, opaque and floury on section the reverse holds good

The *bran* (pericarp) is found to consist of two distinct layers

1 An outer layer consisting entirely of fibres of cellulose impregnated with mineral matter *This is the layer which is removed in the decortication of wheat*

2 *An inner layer consisting chiefly of small cells full of pigment* which give to the bran its brown colour This layer is much poorer in cellulose than the first

The outermost layer (the *Aleurone Layer*) of the endosperm consists of a single row of large cells containing a fine network of protein matter enclosing small globules It contains least cellulose of all and is removed with the bran This layer has always intrigued dietitians and claims are made for its importance because it contains proteins of high biological value usually lost with the bran. The scutellum had been overlooked until 1944 when Hinton[1] showed that it contained on the average 59 per cent of the total thiamine of the whole wheat

The *germ* consists of a mass of small cells rich in protein and fat, but its more minute structure does not concern us

The wheat grain may be used as a food in its entirety Soaked

[1] HINTON (1944) *Biochem Journ* 38, 214 WARD (1943) *Chem and Industry* 62, 11

in water till it swelled up and burst and then boiled in milk with the addition of sugar and other ingredients it formed the old and very nourishing dish called *frumenty* which is now however, but seldom seen on the table and is very difficult to masticate

Far more commonly it is reduced before eating to a state of meal or flour by the process of **grinding or milling** Now it is an exceedingly difficult matter, owing to its toughness, to reduce the bran of wheat to a powder by grinding It can be done but the trouble and expense entailed are great Graham[1] bread is made from whole wheat flour in which the bran has been finely triturated As the bran in normal whole wheat is coarse unpleasant to eat and irritating to many alimentary tracts attempts have been made from earliest times to separate the bran from the rest of the flour

From Norman times until the forties of last century the usual mode of grinding corn was between mill stones made from mill stone grit The lower horizontal stone was stationary the upper revolved The cleaned wheat was fed through the axle of the upper stone and passed between the two stones out towards the circumference being cracked broken and ground to powder in the process This cracking, breaking and grinding was facilitated by grooves cut in the stones and this grooving had to be renewed frequently The dust thus worn off the stones mingled with the flour The resulting flour was 100 per cent whole meal and is still the aim of those who maintain that man should eat whole food as presented to him by Nature It contains coarse bran, finer bran endosperm stone dust and germ mixed together

Such wholemeal flour produces a bread which is unpalatable to many and upsetting to many alimentary tracts From Norman times it has been the custom to sieve off the bran by means of bolting cloth originally made from wool or linen but to day made from silk By consent flour from which the coarsest bran particles are removed consisting of about 92 per cent of the original wheat is called wholemeal though of course it is nothing of the sort Further bolting removes the finer bran and in the end a flour passably white is obtained It represents about 75–80 per cent of the grain What is removed is the fine and coarse bran what remains is the endosperm and some if not all of the germ Such a flour is known as standard stoneground flour and was until the war of 1939–45 obtainable by those who preferred that sort of flour

The Norman baron and his wife preferred white flour and

[1] Sylvester Graham was an American vegetarian *Floruit* 1840 His name is still honoured in Germany DRUMMOND and WILBRAHAM (1939) *The Englishman's Food*

the bread made from it, to the coarser bread made either from unbolted flour or the mixture of rye and wheaten flour which was the lot of the serfs The city merchants naturally imitated the aristocracy to the intense indignation of the latter and preferred white bread to 'black or brown As naturally, to eat white bread became the mark of aristocracy and plutocracy, and brown bread the badge of poverty Some remnant of this survives to this day At any rate whiteness of flour became desirable and milling evolved in the direction of producing a whiter and whiter flour

In the eighteen forties a new method of milling was begun—crushing between rollers rather than between stones This was named the roller process It won its way first in Austria Hungary milling the hard Hungarian wheat and it gave Vienna its well known supremacy in bread and pastry making It did not make its way into Great Britain till about 1880 for there was difficulty with the rollers and with the type of wheat Roller milling succeeds best with the hard wheat such as we now obtain from Manitoba and not with the soft English wheats Roller milling has now practically replaced stone grinding and for reasons that appear by no means scientific has received the execration of most dietitians

The Roller Process The wheat after having been separated from 'foreign bodies' such as nails nuts coin wire paper, shrivelled grain maize oats corn cockle seed and other seeds is washed dried and sucked to the top of the mill Thence it is fed by gravity between parallel horizontal hard steel rollers about 6 ft long The distance apart of these rollers can be adjusted to one thousandth of an inch Both rollers have spiral grooves cut in them but the pitch of the upper spiral differs from that of the lower The grain passes between the rollers and in doing so is caught by the spiral grooves and cracked or broken This is called the first break" Some bran is cracked away from the endosperm and germ some of the endosperm is cracked and broken as well The resulting mixture then passes between two parallel smooth rollers which continues the process some flour—i e ground endosperm—being produced at this stage The bran is blown off the flour sieved off and the remainder consisting of broken grain semolina and germ passes to the top of the mill again The flour produced at this first break is a darkish flour—in milling parlance it has no colour for colour means white

The unground part of the mixture is ready for the second break It passes between grooved rollers again but the rollers are closer together, the grooves shallower and the pitch of the spirals not so

great Again the grain is further cracked bran sheared off and flour produced for after the break the resultant mixture passes between smooth rollers set closer together than the first pair The flour sieved off at this stage—second break flour—is with the third break flour the whitest there is

It is usual in the best mills in Great Britain to have four breaks only but American and Canadian mills have pushed the breaks still further to get off the last remnant of endosperm from the bran

The germ sticks to the third pair of smooth rollers and being scraped off them is collected as a separate fraction In fact roller milling is an elaborate semi automatic cheap and efficient way of fractionating wheat into its constituent parts and represents an advance on the cumbrous method of stone grinding If an attack is to be made it is not on the process itself but on the use the millers and public have made of the process If we want the germ for making germ bread or Bemax we have it If we want pastry whites then we take the second and third break flour representing about 40 per cent of the wheat seed If straight run flour we add the four breaks together So called whole meal can be synthesized by adding to straight run flour the fine bran and the germ The roller process has given us much more control over what we get from wheat and what we make from it—we have to see that we make the right things [1]

There are further practical advantages in this fractionation The white flour keeps better than the stoneground white flour Some of the germ possibly and the oil and diastatic ferments of the germ are present in the stoneground flour The oil oxidizes and goes rancid and the flavour of the flour depreciates The germ produced by the roller mills can have its ferments destroyed by cooking with superheated steam and then be ground to a fine meal for the manufacture of germ breads (Smith s patent)

Hovis flour consisted till the war of 1939–45 of one part wheat germ meal to three parts of ordinary flour It therefore contained more protein more fat more vitamins of the B complex than ordinary or even than wholemeal flour and produces a bread more flavoursome than white without many of the disadvantages of bread made from wholemeal flour

Then too the bran separated from the flour forms food for domestic animals which possess alimentary tracts competent to deal with it e g the horse cow pig and hen and it is a debatable

[1] Any chemist would prefer straight phenol and the rest to crude tar and a technician octane petrol medicinal paraffin lubricating oil and paraffin wax to crude oil

(and debated)[1] problem whether it pays us better to feed the offals to the cow and the hen and get a return in first-class protein or to eat the bran ourselves at first hand In time of war it has always appeared reasonable to increase the amount of bran in the flour for making pastry and bread If we ourselves eat a greater percentage of the wheat kernel we do not need to transport so much wheat In the Napoleonic wars it was so and in the two World Wars Some countries—Eire and South Africa—went as far as 100 per cent extraction We compromised at 85 per cent extraction with a small dilution with home grown barley meal oatmeal and rye at the time of greatest urgency But as soon as possible we got rid of the additions and in 1944 began to reduce the percentage extraction towards the 72 per cent level again By 1945 it reached the 80 per cent level and the Minister of Food proclaimed it as 'nutritious' as the 85 per cent extraction flour[2] while many people interested in nutrition consider this a grave error of judgment

This is clearly the place to attempt an objective account of the hundred year old controversy of white versus wholemeal with the warning that so many factors of prejudice are involved—conservatism gastronomy, bowel consciousness vested interests and politics—that scientific principles even among the scientists themselves disappear into a fog of unproved assertions

The main uses of flour are in the production of bread pastry and other confectionery and biscuits For the last English wheat flour is preferred with its low protein content while for bread and confectionery a flour with more rising power is desired The proteins of wheat gliadin and glutelin when mixed with water, form an elastic paste which can be stretched considerably without breaking Flour containing much gluten can be blown up into a sponge by forming carbon dioxide within it This can be brought about either by the use of yeast by baking powder or by actual aeration with carbon dioxide under pressure A sponge so blown up on baking 'sets' i e the gluten is coagulated and the form of the blown out sponge retained The bread cake or pastry so made is light in comparison with similar products made from the other cereal flours Rice flour and oatmeal will not make bread Rye flour by itself makes a badly risen soggy bread and is usually mixed with wheaten flour in making the bread eaten

[1] See WRIGHT (1941) *Chem and Ind* 60 623 BACHARACH (1941) *Chem and Ind* 60, 791

[2] In the sense in which dietitians use the word nutritious this is not true for if we wish to retain the maximal amount of the nutrients 85 per cent extraction should be maintained

on the continent of Europe and by immigrants from mid Europe into this country and doubtless into the United States Barley meal also has to be mixed with wheat flour to produce a bread or pastry Wheats differ from one another in their capacity to form a sponge The soft wheats of Great Britain have a lower gluten content than the hard Hungarian or the Manitoba wheats The bread made from them does not rise as well as that from the harder wheats and Vienna owes its pre eminence in con fectionery to them The name Vienna' has passed into currency for the lightest bread made in this country though it is not made with Hungarian wheat flour But it is not only the amount of gluten which determines the power to form a good sponge Other factors such as the presence of other proteins than gliadin and glutelin, of bran and of different amounts of mineral elements also affect that power

There is everywhere a movement towards standardization of manufactured food products The purchaser prefers a bread a beer or a butter which always looks the same tastes the same and has the same texture Consequently millers and bakers prefer a white flour, not only because it has better keeping qualities under prevailing conditions but because it bakes bread and other com modities of a more standardized quality The public rightly or wrongly likes white bread because of its whiteness which they confuse with purity because of its texture in eating and possibly because of a traditional belief that to eat brown bread is a mark of social inferiority As Renner points out, the gastronome dislikes the variation in texture produced by bran in the bread and by the crust so that he removes the crust from toast and sandwiches[1] The millers and bakers are out to give the public what it wants without consideration of dietetic values and so take the utmost trouble to standardize the flours they produce They dislike English wheat flour with its low rising power its high water content and its variability and before the second World War resented the compulsion to use 20 per cent of home grown wheat They preferred Canadian, Argentinian and Australian wheat because they could blend them to produce a standardized flour which gave (i) more loaves to the sack and (ii) more standardized bread etc Flours with germ proteins in them varying quantities of mineral elements diastatic ferments and so on need varying amounts

[1] RENNER (1944) *The Origin of Food Habits* 41 The odd thing is that toast crusts by themselves are a pleasant form of food but attached to the toast they are an offence a thing which any gastro nome may prove for himself An anomaly is that he likes ice-cream made with brown bread crumbs as an ingredient

(and debated)[1] problem whether it pays us better to feed the offals to the cow and the hen and get a return in first class protein or to eat the bran ourselves at first hand In time of war it has always appeared reasonable to increase the amount of bran in the flour for making pastry and bread If we ourselves eat a greater percentage of the wheat kernel we do not need to transport so much wheat In the Napoleonic wars it was so and in the two World Wars Some countries—Eire and South Africa—went as far as 100 per cent extraction We compromised at 85 per cent extraction with a small dilution with home grown barley meal oatmeal and rye at the time of greatest urgency But as soon as possible we got rid of the additions and in 1944 began to reduce the percentage extraction towards the 72 per cent level again By 1945 it reached the 80 per cent level and the Minister of Food proclaimed it as nutritious as the 85 per cent extraction flour,[2] while many people interested in nutrition consider this a grave error of judgment

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[2] In the sense in which dietitians use the word nutritious this is not true for if we wish to retain the maximal amount of the nutrient 85 per cent extraction should be maintained

0 2 per cent in white flour and as high as 2 6 in 100 per cent whole meal

But except for vitamins of the B class the case is by no means so complete as the above figures seem to show Percentage composition by no means spells availability Because wholemeal contains more protein, more calcium and more iron it does not follow that the body absorbs more of them In fact, from the early work to the present day experiments comparing the absorbability of the constituents of foods with much roughage with that of foods with little, have shown that though the rough foods may have more of the proximal nutrient materials, the effect of the peristalsis the roughage produces in the human gut is that the body often picks up less This has been investigated for bread for rye bread and for rice among other foods, and the results all point in the same direction

For example Macrae[1] and colleagues investigated the energy, protein and fibre "digestibility" of white bread from 73 per cent extraction flour, and of wholemeal bread from 100 per cent extraction flour of two degrees of fineness of milling They found that 90 1 per cent of the energy value 91 per cent of the nitrogenous substances and 65 8 per cent of the fibre of white bread were wholly absorbable whereas the figures for fine wholemeal bread were [illegible] 9, 85 3 and 14 per cent and of the coarser wholemeal bread 87 1, 85 7 and 9 7 per cent respectively As regards energy value—and we consider that the chief reason for eating cereal products is their energy value—the lower extraction flour wins Taking the energy values of white and wholemeal bread as approximately equal the body obtains 5 per cent more Calories from a pound of white bread than from a pound of wholemeal Of course this means but 50 Calories all told which is it is true, very little to boast about, and it may be purchased at too great a cost Turning to the protein intake by the mouth we find that though the wholemeal bread furnishes 2 91 grammes of nitrogen say 18 grammes of protein per 100 grammes the white bread furnishes but 2 7 (say 16 7 protein) This, however is offset by the larger amount of nitrogen lost in the faeces when on wholemeal bread The net absorption is almost the same viz 14 8 and 15 2 the difference being of the same order as the error of the experiment[2]

[1] MACRAE BACON HUTCHINSON and McDOUGALL. (1941) *Chem and Ind* 60, 723

[2] It must be admitted that the analyses of bread vary within some what wide ranges If we applied Macrae s results to bread showing the analyses given by McCance and Widdowson we should find the argument in favour of wholemeal (92 per cent extraction) Such an application would however not be reasonable

of yeast in the making of bread and baking powder and eggs in the manufacture of confectionery

The change over from the stoneground flours mainly of English origin to roller ground flours mainly of foreign origin has been an inevitable process Nor was that change over in the nature of the flour quite so rapid as has been claimed by the opponents of the roller process Great Britain did not suddenly change to a "devitalized" flour with the introduction of the roller process Thus in 1786–91, Wyatt of the Albion Mill, claims that the 55 per cent extraction flour was used in the white bread in general consumption in London [1] The degringolade from high extraction to low extraction flour was well under way a hundred years before the introduction of the roller process into Great Britain

But though the change over was almost inevitable it does not follow that dietetically it was sound The arguments for and against the use of white flour are set out below, but the reader must bear in mind—a thing too readily forgotten—that both white flour and wholemeal flour *by themselves*, or made into bread are bad foods

Wholemeal, whether 100 per cent or the usual 92 per cent extraction contains more protein and protein of a higher biological value, more B_1 (thiamine), riboflavine nicotinic acid calcium phosphorus iron and roughage than white flour Therefore say the upholders of wholemeal flour, it is better for us All the statements in the first sentence of this paragraph are true and it appears at first sight that the case against white flour is complete

The figures given by the Medical Research Council [2] are as follows

	Protein g	Calcium mg	Iron mg	Vitamin B_1 µg	
100 per cent extraction English flour	9 1	36	3 1	204	per 100 grammes
70 per cent extraction English flour	8 1	19	1 4	87	
100 per cent extraction Manitoba flour	13 9	28	3 9	363	
70 per cent extraction Manitoba flour	13 1	13	1 8	60	

For riboflavine and nicotinic acid the differences though great are not so pronounced but the fibre (roughage) may be as low as

[1] RICH (1941) *Chem and Ind* 60, 611 Rich also states that the belief that much of the germ passes into the 75 per cent extraction flour produced by stone grinding is untrue

[2] *Nutritive Values of War Time Foods* (1945)

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So far the results lead us to prefer neither white nor wholemeal flour to the other, but there is the question of the biological value of the proteins. Unfortunately this has never to our knowledge been measured for man but only for the laboratory rat. Chick and Work[1] showed that though the availability to the rat of 75 per cent. extraction flour, national wheatmeal flour and wholemeal flour was 89, 86 and 84 per cent. respectively, the young rat grew faster by some 30 per cent. on the wholemeal than on the white flour when it formed the only source of protein in their diet, national wheatmeal giving an intermediate value. Such observations have great value. But it may be pointed out that to apply rat feeding experiments directly to man is not wise. Even in the lowest stratum of human society in this country man does not live on bread alone. Indeed the governmental policy during the second World War has been to supply the rapidly growing young with a cheapened source of protein of high biological value in milk, the effects of which swamp the small beneficial effects of the higher biological value of wholemeal. It is wiser to continue our efforts to supply everybody with sufficient milk than to insist on a greater degree of extraction of wheat. Until we have experiments on young growing children comparable to those on the laboratory rat, the experiments quoted must remain as a possible pointer only. The rapidly growing rat might well show the effect of the higher biological value of wholemeal less ambiguously than the child. The rat certainly has the power of extracting other things from cereals which the human being does not possess. (See below.)

Then comes the problem of the mineral elements of cereals. The important ones are phosphorus, calcium and iron, of which wholemeal certainly possesses more than 72 per cent. extraction flour.

Phosphorus. White flour has 102 milligrammes per 100 grammes, national wheatmeal 206 and wholemeal (92 per cent. extraction) 287. This appears to be at first sight all in favour of high extraction. But is phosphorus in these amounts essential? Throughout their extensive investigations into diets in this country, McCance and Widdowson have never met diets deficient in phosphorus. Whatever else may be lacking—calcium, iron, protein and vitamins—phosphorus is always there. Moreover the phosphorus in cereals antagonizes the absorption of calcium whether it be there as phytates or as phosphates.[3] Free phosphates impede

[1] Chick and Work. (1941) *Chem. and Ind.* 60, 723.
[2] McCance and Widdowson. (1942) *The Chemical Composition of Foods.*
[3] McCance and Widdowson. (1942) *Journ. Physiol.* 101, 44, 304.

the absorption of calcium whereas the phytates in 92 per cent wholemeal, not only prevent the body from obtaining the calcium in wholemeal, but actually prevent the body from obtaining some of the calcium from other sources such as milk cheese and fish It has been calculated by McCance and Widdowson that 1 lb of wholemeal bread would blanket the calcium in $\frac{9}{10}$ of a pint of milk In the long run with the consumption of milk in this country so low as it is it would be wrong to insist on higher extraction of wheat until the production and consumption of milk is increased by at least 50 per cent This will take many years

On the score, then of phosphorus content, wholemeal is a dangerous food

Calcium In calcium content wholemeal flour beats white flour The figures given by McCance and Widdowson[1] are 34 8 milligrammes and 18 4 milligrammes respectively Assuming the calcium to be equally available from each—which we have seen they are not—wholemeal provides double the amount of calcium that white flour yields Put in that way, as it often is by those who believe in wholemeal it sounds convincing But put in the common sense way of saying how much wholemeal flour one would have to eat per day to obtain 680 milligrammes the argument becomes ludicrous To obtain all the calcium needed by an average man per day, he would have to eat $\frac{100 \times 680}{34\ 8}$ or approximately 1950 grammes (i e over 4¼ lb) This as bread would be some 6¼ lb —an impossible amount To eat 1 lb per day is an achievement except when taking strenuous exercise Besides which—to continue flogging a dead horse—the calcium of wholemeal is unavailable All cereals are poor sources of calcium and what they have is often unavailable and almost certainly unavailable in whole cereals and whole cereal products

Iron Again we find that wholemeal (92 per cent extraction) has more iron than white flour Figures from McCance and Widdowson s tables are 3 55 milligrammes per 100 grammes wholemeal, 2 36 milligrammes for National wheatmeal and only 0 92 for 70–72 per cent extraction flour Moreover, it has been shown that the laboratory rat made anæmic by a diet of white bread and milk can be restored to a normal state of the blood by whole cereals The rat obtains insufficient iron from white flour but can gain sufficient from whole cereals Consequently the assumption was made that the anæmia so often found in the poorer classes of this and other countries devoted to highly milled cereals is due to the deficiency of those cereals in iron And

[1] *op cit*

here, among others, we must pillory ourselves, for in the 9th Edition of this book we recommended wholemeal bread for its pleasant flavour and its iron[1] This illustrates the rashness of applying facts discovered in the rat directly to human dietetics without criticism It had been known that of the metallic phytates, iron phytate is particularly insoluble Consequently it might have been guessed that the phytates of whole cereals would impede iron absorption from the human gut This is true In prolonged experiments by McCance and Widdowson the percentage absorption of the iron present in the diets of four men and four women sank measurably when the white bread in their diets was replaced by wholemeal bread of 92 per cent extraction[2] Though there was 50 per cent more iron in the wholemeal bread diet, they absorbed less of it Two of the women actually went into negative balance on the wholemeal bread diet The authors of this work cautiously suggest in their summary of the experiments that "in spite of the large amounts of iron in whole wheat, bread made from it may not be as good a source of iron as is generally supposed"

Why then do rats recover from a nutritional anæmia produced by white bread and milk when given whole wheat? Simply because they possess a phytase in their alimentary tract which splits the inositol hexaphosphates into inositol and phosphates So little a difference does it take to render experiments on rats nugatory when applied to human beings!

It is true that cereals do contain phytases, but in the case of wheat not enough to split the whole of the phytates in bread making[3] In rye bread baked according to German technique, 45 per cent of the phytates were destroyed by the active phytase of rye but much less disappears in wheaten bread

So on the score of iron, as well as of calcium a 70 per cent extraction flour is more beneficial than a long extraction Generally speaking, the high mineral element content of wholemeal flour gives it no advantage in diet over white flour but rather the opposite

Vitamins Both white flour and wholemeal flour are deficient in vitamins A, C and D It was once thought that wholemeal contained some vitamin A but to day this opinion has been relinquished The Medical Research Council's tables[4] put its

[1] *Food and the Principles of Dietetics* (1940) 133

[2] McCance and Widdowson (1942) *Lancet* 1, 588

[3] McCance and Widdowson (1944) *Nature* 153, 650

[4] *The Nutritive Values of War Time Food* (1945) Some workers claim that what there is is equally distributed between endosperm and the rest of the wheat berry

content of A as zero So there is nothing to choose between the two flours when considering vitamins A, C and D They have none Wholemeal flour will have vitamin E which is of problematic value in human nutrition But as we have said, the B vitamins are much better represented in wholemeal flour than in white Both the germ and the bran contain more thiamine riboflavine and nicotinic acid than the endosperm Of the total thiamine in wheat, the germ has 15-20 per cent, the bran 60 per cent and the endosperm only 25 per cent [1] This estimate has to be modified somewhat, for it has been found that the scutellum contains 50 per cent of the total thiamine of the wheat [2] This probably in ordinary milling is included with the germ, but if it could be retained by "dry milling in the endosperm, much higher amounts of thiamine would be present in white flour, enough to lay the bogy of avitaminosis B_1 which so terrifies the B enthusiasts It would be possible to obtain a 70 per cent extraction flour with no germ or bran in it yet having the thiamine content of national wheatmeal flour [3] It must be mentioned that all wheats have not the same thiamine value It is usually assumed that their value is about 1 6 I U per gramme [4] It may be higher Figures have been given as high as 5

With nicotinic acid the story is much the same it is to be found concentrated in the bran the coarsest bran having most Thus whereas English wheat may have 48 microgrammes per gramme and Manitoba 55–66, commercial germ has 55–77 and the bran 267–325 A 45 per cent extraction white flour from English wheat has only 5 0 a 70 per cent 7 5 an 85 per cent 10 5 and 100 per cent 48 Similar but rather higher figures are given for Manitoba wheat the 1943 wheats having a particularly high titre [5] National Wheatmeal flour 85 per cent extraction gave figures ranging from 12–18 7 microgrammes per gramme One pound of national wheatmeal flour would give about 5½ milligrammes of nicotinic acid a very considerable amount whereas a 70 per cent extraction white flour would give but 3¼–3¾ milligrammes The change to 85 per cent extraction flour has caused the disappearance

[1] Rich (1941) *Chem and Ind* 60, 611

[2] Hinton (1944) *Biochem Journ* 38, 214 Ward (1943) *Chem and Ind* 62, 11

[3] Ward (1943) *op cit*

[4] Rich (1941) *Chem and Ind* 61, 611 Copping (1945) in a conference of the Nutrition Society Feb 24th, gave figures 2 8–8 5 $\mu g/g$ = 0 28–0 85 mg /100 g = 0 93 I U to 2 83 I U per gramme or 93–283 I U per 100 grammes

[5] Barton Wright (1944) *Biochem Journ* 38 314

of pellagra among the mental patients in an institution to which one of us (G G) has access Previously, 4 or 5 patients who were "difficult" over their food had mild pellagra each year

With riboflavine the distribution between bran, germ and endosperm is more even than with B_1 and nicotinic acid but still the endosperm has least [1] Therefore as regards the B complex of vitamins nutrition experts must favour high extraction, though it must not be forgotten that the microbes of the large intestine contribute to the body significant amounts of these vitamins and it is possible that cereal residues give a less satisfactory pabulum for these microbes than say, milk residues Maize contains about the same amount of nicotinic acid as milk, yet milk can cure or prevent the pellagra arising from eating maize!

There remains only roughage to consider It, or its decomposition products in the large intestine stimulate that organ to peristalsis It is generally asserted that some roughage is of assistance to the regular emptying of the large intestine There is no doubt that whole cereals provoke in the majority of people a much more frequent evacuation up to thrice a day, of the large intestine Some alimentary tracts are much more irritable than others *Many cannot tolerate a 100 per cent extraction material.* Indeed there have been frequent grumbles at 85 per cent extraction National Wheatmeal bread on that account though only the fine bran is included in National Wheatmeal flour It is impossible to say how much this fear of the large intestine, inculcated in people by nurses relatives and the patent food and medicine advertisements, renders them bowel conscious" and so queers their capacity for sound observation It has been said that it is somewhat hard on those who have no trouble with their colons to be condemned to frequent and bulky stools in order that the constipated should have regular motions [2]

To sum up the whole problem as it stands at the present day

(i) There is no advantage in higher extraction flours as regards protein absorption

(ii) There may be slight advantage in them as regards the biological value of their protein

(iii) High extraction flours are much worse than low extraction flours where calcium and iron absorptions are concerned and this is mainly due to their high content of organic and inorganic phosphorus compounds

[1] Cereals in whatever form are a poor source of riboflavine

[2] ROBERTSON (1943) *Chem and Ind* 62, 222

(iv) Both high extraction and low extraction flours are valueless as sources of vitamins A C and D

(v) High extraction flour is much better than low extraction flours for the B complex of vitamins

(vi) High extraction flour sometimes provokes frequent and bulky evacuations of the large intestine which may or may not be advantageous

It is clear that some compromise between high and low extraction is advisable, and we think that the introduction of National Wheatmeal flour of 85 per cent extraction [1] containing the fine bran, the aleurone layer, the scutellum and as much of the germ as possible and having a thiamine content of nearly 1 I U per gramme, was a wise move from a wholly dietetic standpoint and that the fortification of this flour with calcium to offset the phytate effect was an admirable step Further, we consider that this standard should be maintained until the agriculture of this country has been so reformed that there is plenty of milk cheese eggs fruit vegetables and bacon for everyone and the economic conditions so changed that everyone can purchase them As regards wheat the task of the growers is to produce wheat with higher amounts of the B complex of vitamins and the task of the millers is to see that these vitamins find their way into the lower extraction flours demanded by public taste

[1] It is interesting to note that the amounts of the useful nutrients in wheat flours—particularly vitamin B_1—show a sudden drop if the extraction be below 85 per cent Even 82½ per cent extraction flour shows a marked decrease The change to 80 per cent extraction we feel to be a mistake We append an analysis by McCance and others (1946) *Bioch Journal* 3v 213 *q v*

COMPOSITION OF MANITOBA AND ENGLISH FLOURS

Extraction.		Protein (N × 6 7)	Fat	Carbohydrate as starch.	Fibre.	Calories per oz	Vitamin B	
		g per 100 g						
Manitoba	80 per cent	13 2	1 4	68 8	0 13	96	65 I U	per
	85	13 6	1 7	67 2	0 33	97	[illegible]	100 g
English,	80	8 2	1 3	73 5	0 19	96	60	
	[illegible]	8 6	1 5	72 0	0 42	95	[illegible]	

Extraction.		Riboflavine	Nicotinic Acid.	Calcium.	Iron.	Total Phosphorus	Phytate Phosphorus
		mg per 100 g					
Manitoba	80 per cent	0 08	1 1	15 4	—	139	63 4
	85	0 10	1 3	18 5	—	188	96 1
English	80	0 08	0 9	21 5	1 65	118	57 8
	85	0 12	1 1	24 5	2 22	153	72 8

Cookery of Flour—Bread

In order to make flour available as food, it must be cooked in some way or another The simplest method is to mix the flour with water and bake it It is in this way that *ship's biscuit* is manufactured The product, however, is of an almost flinty hardness, and not easy of mastication Hence the problem early arose how to cook the flour in such a way that it would be light and easy of digestion It was solved by causing gas to develop in the mixture of flour and water, so converting the latter into a kind of sponge, which was subsequently baked, and into which the digestive juices can easily penetrate In other words, man learnt to make *bread* Now, the making of bread from flour is only possible because the latter contains gluten Gluten is a mixture of proteins which has the peculiar property of becoming viscid when mixed with water If the viscid mass is then blown up with gas, it has sufficient cohesion to remain in the form of a sponge or honeycomb instead of collapsing again, as it otherwise would do, and allowing the gas to escape As we have said above, most other cereals, such as barley, rice, and oatmeal do not contain gluten, but other forms of protein, which do not become viscid when moistened and consequently out of these bread cannot be made

The next question is, How is the gas, which is to be used to blow up the dough, produced ? The reply is that the earliest method of producing the gas and that which is still by far the most widely used, was by *fermentation* There are in the air " wild " yeasts which falling on a wet dough produce from the sugar in the dough alcohol and carbon dioxide [1] This must have been the method by which the Egyptians and the Jews " leavened " their bread Some dough reserved from the last baking was added to a fresh dough, the yeast it contained grew with great rapidity through this dough till all was *leavened* and filled with bubbles of gas [2]

In more modern times strains of yeasts have been produced commercially and standardized and these are what are used to day for the manufacture of bread

[1] Amos (1942), *Chem and Ind* 61, 117, has given convincing evidence that the flour itself contains a yeast which must be responsible for the gasification of the barm in the Scottish method of making bread and possibly in the leaven of Biblical times This paper and the relevant chapters of *Modern Cereal Chemistry* by Kent-Jones should be consulted by anyone interested in the reasons for the different flavours and textures of bread in various parts of the British Isles

[2] This method was still actually in use in remote farmhouses in the early childhood of the authors

It is not the object of this book to deal with processes of cooking except in so far as they bear upon dietetics, so no elaborate account of the baking of bread is given here That is left to trade journals and cookery books but we cannot refrain from saying that the latter make the process of breadmaking terrifyingly elaborate, whereas it is so easy that almost anyone can make a success of it

In using yeast to make bread, the first thing the baker has to do is to get his yeast to increase and multiply This has two advantages it enables an originally small quantity of yeast to suffice for a whole sack of flour and it produces a more active yeast for the young cells are more energetic than those which are older This stage of bread making is called the preparation of the *ferment* The yeast is mixed with sugar and warm water and put in a warm place till it froths up This takes but a short time The invertase of the yeast splits the cane sugar to glucose and fructose and the zymase within the yeast cells begins the fermentation of the glucose to carbon dioxide and alcohol There are other and more elaborate ways of producing a ferment e g by the use of potato gruel flour and yeast but the object is to obtain an actively growing yeast [1]

This ferment is then mixed with warmed flour and warm water and the whole kneaded into a dough The yeast continues its production of carbon dioxide within the dough, partly at the expense of the sugar added and partly by working on the maltose produced by the diastatic ferments of the flour acting on its starch The dough is thus blown up into a sponge like texture It rises How long it is left to rise varies greatly and depends largely on the amount of ferment used and the temperature of the surroundings It can be as little as 20 minutes In the usual household practice it is an hour In commercial bakeries it is about 4 hours but it may be in more economical parts of these islands much longer still This has some bearing on the destruction of the phytates present The longer the dough is "proved" the more work the phytases of the flour can accomplish with advantage in reducing the rachitic effect of cereals

When the dough has risen to about 1½ times its original volume it is usual to knead it thoroughly again leave it again to rise in a warm place and when it has sufficiently risen to weigh out portions and bake it at a temperature of 400°–450° F This second kneading invariably carried out in commercial practice and in domestic science colleges can be omitted both with wholemeal bread [2] and with white bread in the household [3]

[1] See AMOS *op cit* [2] GRANT (1944) *Your Daily Bread*
[3] Personal communication from two housewives

The baking causes the gas in the dough to expand and blow the latter up so that it becomes full of little cavities The heat also hardens and coagulates the proteins in the flour Some of the starch on the outside is converted to soluble starch and dextrin and forms the crust It is to the dextrin that the crust owes its glazed appearance Altogether about 8 per cent [1] of the starch in the loaf is thus converted Some caramel also is formed, and helps to give the crust its flavour and dark colour When these changes have taken place the dough has passed into the form of bread

Changes involved in Baking It will be obvious that any process of making bread by fermentation necessarily implies an amount of waste The amino nitrogen of the flour forms a pabulum for the yeast [2] Other organisms break down some of the protein to amino nitrogen The sugar of the flour is utilized by the yeast and starch split into sugar This produces, as said above alcohol and carbon dioxide The gas diffuses out of the bread and the alcohol is mostly driven off by the heat of the oven It was calculated that as long ago as 1879 300,000 gallons of alcohol were annually lost in this way in the ovens of London alone It does not pay to recover this alcohol Totalling these losses it has been calculated that as much as 7 per cent of the total solid ingredients of the dough are lost

The consideration of this inevitable waste led to attempts to convert dough into a porous form by other methods than that of fermentation One of these was the method of Dauglish In this process carbon dioxide was prepared in the usual chemical way, water was saturated with it at 7 to 10 atmospheres and the dough was mixed with this in an air tight chamber Then the pressure was lowered and the dough allowed to expand was cut into loaves and baked at once The product was known as *aerated bread* The process has, however, fallen into desuetude The bread so produced had a raw and insipid flavour

Results similar to the above are also obtained by the use of ***baking powders*** These consist of mixtures of various chemical substances which have this in common, that when moistened the ingredients of the powder act upon one another carbonic acid being given off If therefore the powder has been thoroughly mixed with the flour, and water is added, the gas will be liberated all through the resulting dough and the latter will be thoroughly aerated These powders consist of either tartaric acid or potassium hydrogen tartrate with bicarbonate of soda Some used in the U S A have alum in them A means of introducing calcium into

[1] *U.S Dept of Agriculture Bull* 67 [2] AMOS *op cit*

bread would be to make precipitated chalk the basis of a baking powder The tartaric acid powders are the most efficient, for they give off twenty five times their volume of gas, the cream of tartar powders yield only thirteen volumes, and alum powders not more than seven to eleven In all of these powders the soda is slightly in excess so that the end reaction of the chemical process is alkaline There is thus no possibility of their rendering the bread sour "Self raising flour is flour with which baking powder has already been mixed Although the use of baking powders obviates the protein and carbohydrate loss from the dough there is considerable destruction of vitamin B_1 which does not occur when yeast is used In yeast made bread the loss is about 10 per cent In baking powder made bread the loss may be as much as 100 per cent depending upon the final P_H reached Hence baking powders should not be used if there is any fear of lack of vitamin B_1

No matter by what process a loaf is made, it possesses when finished certain characters by which bakers judge of its quality It should be well risen' and possessed of a thin flinty crust which is neither very light nor very dark in colour and cracks on breaking The crumb should be elastic in consistence of uniform texture without large holes and of a smooth and silky pile It should have a sweet nutty flavour and odour and in colour should be of a creamy whiteness Curiously enough when bakers speak of a loaf having no colour' they mean that it is rather dark whereas high colour signifies with them great whiteness It must be admitted however that the above characters however important æsthetically are not of much value from a nutritive point of view Especially is this so in regard to colour A very white loaf means a loaf in which starch is at a maximum and protein at a minimum and that is theoretically not desirable For setting up a false standard of whiteness the baker is not to blame It is the ignorance of the public which mistrusts a dark loaf

The Chemical Composition of Bread Two-thirds of the volume of a good loaf is made up of gas (Fig 15) and of the solid part about 40 to 50 per cent by weight consists of water so that bread is one of the least watery of vegetable foods, and is relatively much less so than raw meat [1] The composition of the

[1] The great variability in the amount of water met with in bread renders it desirable that some standard of moisture should be fixed the exceeding of which should be regarded as an adulteration In other words when a consumer pays for a given weight of bread he has a right to expect that his purchase shall contain a definite amount of nutriment The figure given for the water in National Wheatmeal bread in *The Nutritive Values of War time Foods* is 37 per cent

dry residue will obviously depend upon that of the flour from which the bread has been made Especially has one to consider whether the bran and the germ have been left in the flour or not In white bread these have been excluded As regards "brown" breads one cannot speak so definitely, for the term *brown bread* is a vague expression[1] It may simply mean that a certain proportion of bran or of germ or of both have been added to the flour, or it may be applied to bread made from whole wheat meal In each case the resulting loaf will be 'brown Now, bran contains, as we have seen, a good deal of inorganic matter, protein, and vitamins of the B complex One would naturally expect, therefore, that bread

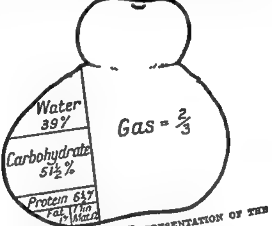

FIG 15 —DIAGRAMMATIC REPRESENTATION OF THE COMPOSITION OF A LOAF

containing bran should be richer in these ingredients than white bread As regards inorganic matter this is certainly true, but it is by no means invariably true of protein The following table shows in round numbers the mean percentage composition of different breads Unfortunately the reader must be prepared to meet analyses which do not agree with those quoted, which are from McCance and Widdowson[2] For example those given by the Medical Research Council[3] for National Wheatmeal bread are Protein 8 5, Fat 1 2, Carbohydrate 51 4 Calcium 57 milligrammes Iron 1 8, Calories per lb 1142 Such variations are inevitable and depend upon the source of the bread and ~ the analyst Dr Sylvester the Ame wholemeal grain, ved

1 Graham flour ıт f the ouncil Special Graham alone cont (194 the outer and more

2 *Chemical Compost* F *Rep* No 235

3 *The Nutritive Val*

COMPOSITION OF WHOLEMEAL AND WHITE BREAD COMPARED

	Protein	Fat.	Carbo hydrate	Cal cium	Iron	Calories per lb
				mg	mg	
White bread (70–72 per cent. extraction)	7 9	0 7	53 7	23 1	1 00	1093
National Wheatmeal bread (85 per cent extraction)	10·0	1 6	46 3	22 3[1]	2 32	1021
Wholemeal bread (92 per cent extraction)	10 8	2 2	44·0	25 3	2 60	1041

There are also various ***patent and fancy breads*** in the market Of the former the different varieties of ***Vienna bread*** are a good example These are made from very fine flour ('patents) fer mented with compressed yeast milk being often added to the dough. The crust is glazed by being subjected to the action of superheated steam before leaving the oven Of the patent breads the majority are of the brown variety They are made from flours prepared by various patent processes Some of them are ***wholemeal*** breads, in which the bran has been reduced to varying degrees of fineness others contain the germ in various proportions of which Hovis is the best known example Others again are ***malted*** The malting of bread consists in adding to it malt-extract obtained by evaporating an infusion of malted barley to a syrupy consistency at a low temperature The solid part of the malt-extract so prepared consists mainly of malt-sugar and dex trins But it also contains the ferment diastase which is able to convert starch into soluble substances (maltose and dextrin) When, therefore malt-extract is mixed with the dough part of the starch in the latter is ultimately converted into malt sugar and dextrin In other words part of the starch is digested This has the effect as already pointed out of making the bread keep longer moist Now, it is important to remember that this ferment diastase is readily destroyed if exposed to a high temperature Hence its activity inevitably ceases soon after the bread enters the oven If then, any considerable part of the starch of the dough is to be converted the malt extract must be added very early in the process As an alternative to that it may be added to a separate part of the flour and the latter mixed with water and kept at a moderate tempera ture till most of its starch has been changed and this mixture

[1] 57 when fortified, according to *The Nutritive Values of War time Foods* (1945)

added to the dough just before baking This is the peculiarity o Montgomerie's process, by which ' Bermaline " bread is made But even in these favourable conditions not much more than 1(per cent of the carbohydrates of the loaf are in a soluble form while in ordinary bread about 4 per cent are so changed Seeing also, that the diastase is destroyed by the act of baking it is obvious that malted bread cannot truly be said to aid the digestion of other starchy foods Detailed analyses of patent breads made by Hutchi son will be found in an earlier edition of this book Any advantage these breads, with the exception of the germ breads have over normal bread lies more in their palatability and flavour than in their nutritive value

Changes which Bread undergoes on Keeping When bread is kept its crust loses its gloss and elasticity and becomes soft leathery and dull At the same time the crumb becomes ' dry ' and hard The crust takes up water from the air and from the crumb The change in the crumb is not only, as might have been guessed, due to loss of water but due to a change in the aggregation of the molecules of starch Starch, according to Kratz who examined its X ray spectrograph has three forms A, that of unchanged wheaten starch, B that of "native" starch and C, that of fresh baked crumb of bread On staling the starch of type C reverts to that of type B This change is reversible and depends on tempera ture and humidity *A stale loaf may be 'rejuvenated ' several times by a short time in a sharp oven* Type B starch is again changed to type C

The *cooking of bread* is practically confined to the application of dry heat This has the effect of driving off water and of rup turing some of the starch grains and converting them partly into soluble starch and dextrin A little caramel also is produced The result is toast Toasted bread has the composition Protein 9 4 Fat 0 8 Carbohydrate 63 8 and Calorie value per lb 1300 (per oz 81) Pulled bread ' is made by pulling out the *interior of a new loaf and thoroughly baking it* The same changes occur in it as in toast only to a greater degree ' Fairy toast or toast Melba *is made from new bread* cut thin and baked in a slow oven till it is a delicate golden brown, or from thick toast which is split down the middle and the fresh side *toasted*

Biscuits are made from fine flour either alone or with the addition of sugar butter milk, flavouring agents, etc *Baking* powder is sometimes added to make them rise a little They contain very little water (about [illegible] per cent) and 3 lb of them may be *taken as equal in nourishment* to 4 or [illegible] lb of bread according to the make of biscuit

Analysis of a number of biscuits made by English firms are given below, attention is called to the high percentage of fat in many kinds, particularly the cream cracker

Composition of Biscuits

	Protein.	Fat	Carbo hydrate	Calories per oz.
Army (round)	13 1	1 2	75 2	106
(square)	11 0	0 3	76 3	103
Bisc-o Ryo	11 90	1 10	76 00	105
Breakfast	10 40	0 20	74 80	123
Chocolate	4 69	6 15	70 20	103
Cornish Wafer	7 25	20 28	58 87	154
Cracknel	11 58	8 38	73 91	121
Cream Cracker	8 08	18 43	70 62	140
Dinner Roll	10 49	6 34	74 39	115
Fancy Lunch	9 86	7 17	78 88	122
	11 60	8 63	72 70	122
Fine Water	11 05	7 33	75 03	120
Fruit Wafer	5 40	10 64	72 18	119
Ginger Nut	6 10	8 60	79 80	110
Horlick s Malted Milk Rusks	9 30	4 30	80 00	116
Mario	7 43	10 80	79 47	129
Milk	9 23	10 72	76 85	125
Nursery	9 33	3 67	78 80	112
Osborne	7 40	11 10	79 59	130
Oval Thin Captain	9 25	6 38	79 46	120
Oval Water	9 96	6 88	78 00	120
P F Shortcake	8 02	26 40	62 40	151
Princess	8 20	24 00	63 10	147
Thin Captain	11 28	1 68	80 31	120
Ryvita	7 4	2 1	86 8	106
Water	8 73	4 07	81 75	116

Rusks may be regarded as a kind of toast They are made in much the same way as bread, but sometimes with the addition of butter sugar and milk and are twice passed through the oven, after which they are thoroughly dried

The Digestibility of Bread The term digestibility in dietetics is a loosely used term to denote a number of properties To the physiologist it means ease and rapidity of digestion and absorption into the blood stream to the physician it means these plus lack of discomfort in the process If the eating of a food is followed earlier or later by pain or discomfort that food is apt to be labelled

"indigestible" It may produce flatulence in the stomach or bowel, it may evoke a large flow of gastric juice and promote excessive peristalsis of stomach or intestine the peristalsis of the stomach and small intestine may hurry the food in a semi digested state into the colon and microbes there may produce flatus offensive or otherwise, the peristalsis may be so great as to cause diarrhœa Any food which *does any of these things is* "indigestible' At one time great attention was paid to the length of time food remained in the stomach but this, we consider, is no sound measure of its digestibility

Voit, in his lectures, used to protest against the idea that awareness of the workings of the alimentary tract indicated that the food eaten was indigestible He maintained that all it showed was that the alimentary tract was at work This we hold to be unfounded for we consider that digestion is best when effortless and unconscious Bread is digestible and absorbable The digestion starts in the mouth by the conversion of its cooked starch and its dextrins into *dextrins and maltose under the influence of the diastatic ferment of* the saliva known as ptyalin The more thoroughly the bread is chewed and ground into small particles, the more complete will the transformation be It is on account of the greater ease with which they can be pulverized by the teeth that toast and biscuits are more easily digested than ordinary bread, and stale bread than a newly baked loaf The dryness of toast and biscuits too, enables them to become easily saturated with the saliva, and that also greatly facilitates digestion Further it must be remembered that a considerable proportion of the starch in biscuits and toast has been already converted into soluble forms in the course of their prepara*tion, so that the labours of the digestive juices* in their case are considerably lightened For these reasons also the crust of bread is more digestible than the crumb, for it is drier and contains a higher proportion of dextrins *owing to the more intense* action upon it of the heat of the oven

The notorious indigestibility of new bread on the other hand, is due to its moistness which makes it difficult to chew and at the same time prevents it from soaking up the saliva Alvarez reports that new bread can pass the whole of the small intestine without becoming digested (Observations upon a patient with ileal fistula)

As regards the ***duration of its stay in the stomach*** bread leaves the stomach with good speed Hawk and Bergheim report that 100 grammes of bread ($3\frac{1}{2}$ oz) leave the stomach completely in $2\frac{1}{2}$ hours This period cannot really be regarded as long when one bears in mind the comparatively large amount of solid matter which

bread contains White bread is disposed of by the stomach rather more quickly than black (e g rye), but there is no appreciable difference in this respect between the behaviour of wholemeal bread and that made from fine flour Biscuits must be regarded as considerably more digestible than ordinary bread in view of the large amount of solid nutriment which they contain

In the intestine the digestion of the starch and protein of bread is completed and *absorption* takes place On the whole white bread is very thoroughly absorbed Even when large quantities are consumed, the loss of nutritive constituents is only about as follows [1]

	Percentage Unabsorbed
Total solids	$4\frac{1}{2}$
Protein	20[2]
Inorganic elements	25
Carbohydrates	3

It will be noted that a great share of loss falls to the proteins This contrasts very strikingly with the case of meat in which the protein is absorbed almost in its entirety

The *carbohydrate* of bread corresponds to the protein of meat in being almost completely absorbed into the blood On the other hand, it is rather surprising to find that of the comparatively small amount of *inorganic elements* met with in bread, one fourth is excreted unabsorbed

We have already (pp 303–17) discussed the still hotly debated question of the relative nutritional values of white and wholemeal bread For the middle classes in peace time this seems as important as the question as to which end you should open an egg The future seems to lie with a fortified bread

On the evidence then bread unless it be new, is a highly digestible and absorbable food It is unlikely to provoke any of the symptoms which will cause it to be labelled indigestible Even the eating of hot newly baked bread, so usual for breakfast in the United States, does not seem to be followed by the symptoms which would be expected in this country Four years' residence in North America by one of us did not reveal more indigestion in that part of the

[1] From the average of a considerable number of experiments by Rubner Atwater Zuntz and Magnus Levy Goodfellow and others The quantities consumed were very considerable amounting to from 600 to 1000 grammes per day

[2] The latest figures quoted above p 311 give the loss of protein as much lower viz 9 per cent for white bread and 11 per cent for 100 per cent extraction wholemeal bread

world than in Great Britain It was common once to speak slightingly of the American stomach, but perhaps that term of abuse may be allowed to pass into desuetude

The Economic Value of Bread Bread is among the cheapest of foods That is why it forms so large a proportion of the diet of the poorer paid classes A labourer, doing heavy manual work, can easily consume 1 lb of bread per day He needs cheap and easily available energy and that is supplied by bread With so much more of our manual work being done by machinery and with an absolute rise in wages of the working classes we may expect the consumption of bread and other cereal products to decrease This tendency was obvious in this country between the opening years of the century and the outbreak of war in 1939 As war circumstances caused a fall in the fat ration, the other main source of Calories the consumption of bread rose again and in diets investigated by McCance and Widdowson before and after the commencement of the war the Calories obtained for carbohydrate almost exactly equalled those lost in fat Bread, then has its prime importance in supplying Calories

It is difficult in a time of fluctuating prices to give figures which will be accurate for more than a year or so But it is easy to work out the cost per thousand Calories given tables and current prices At the time of writing margarine at the controlled price of *5d* per lb gives 1000 Calories at approximately $1\frac{1}{4}d$, of *9d* per lb, at $2\frac{1}{4}d$ Bread at *3d* per lb gives 1000 Calories at *3d*, Cheese at *1s* *1d*, at $6\frac{1}{2}d$, milk at *9d* per quart, at *1s* *0d* jam at *1s* *0d* per lb, at $10\frac{1}{2}d$ and potatoes at *1d* per lb at $2\frac{1}{4}d$ These prices are controlled and some of the foods are at an artificial price due to Government subsidies but even in times of peace bread and margarine helped down with a little jam are the cheapest foods and easiest to prepare In other countries other cereals may take the place of wheat products but the reason is the same cereals are cheap for Calories That is why the Government in the two World Wars has refused to ration bread, and in the second World War kept its price artificially low

Bread, too is by no means a negligible source of protein albeit of second quality In fact a high bread diet entails a high total protein diet 1 lb of bread contains over 38 grammes of protein no mean proportion of the 70–80 grammes held to be essential in the daily diet of an adult In this no other cereal can equal wheat And the cost of wheat protein is low compared with that of other foods Beans at *6d* per lb are the only food which rival bread as a source of protein in price Both give 1 lb for about *2s* *10d* Cheese gives, at *1s* *1d* per lb, the same amount at *3s* *5d*, whereas

with milk the price is 0s 11½d when milk is bought at 9d per quart The serious defects of bread are its low calcium content and its total lack of vitamins A, C and D only in the vitamins of the B complex is bread of use wholemeal being better than white bread There is no escape from the fact that bread must continue to be the largest single element of diet mainly because of its cheapness as a source of energy

Of the patent and fancy breads as a whole it may be said that they are somewhat dearer than white or wholemeal breads One pays for flavour and the patent rights Even ordinary wholemeal bread has ceased to be cheaper than white bread and cannot be recommended on that ground. Here are some analyses of different breads from McCance and Widdowson s tables [1]

	Protein	Fat	Carbohydrate	Calcium	Iron	Calories per oz.
	Per 100 grammes.					
	g	g	g	mg	mg	
Bread:						
Currant	7·0	3 4	45 8	37 6	2 35	66
Hovis	11·4	3 7	40 6	27 5	2 05	66
Malt	9 1	3 3	49·4	53·0	3 21	72
National Wheatmeal 85 per cent	10 0	1 6	45 3	22 3	2 32	65
National[1] Wheatmeal fortified with Calcium	8 5	1 2	51 4	57 0	1 8	74

The most important preparations of wheat flour especially in Italy are macaroni spaghetti vermicelli and the Italian pastes These are made from flours rich in gluten derived from a different species of wheat *triticum durum* whereas ordinary wheat flour arises from varieties produced by thousands of years of selection and nowadays controlled breeding and selection of strains of *triticum vulgare* *Triticum durum* is a hard yellow flinty wheat having a high protein and sugar content [2] It needs a hot climate and is resistant to drought The flour from the endosperm of the wheat is made into a paste with water and the viscidity of the gluten then allows it to be moulded in various ways

[1] McCance and Widdowson (1942) *Chemical Composition of Foods* Med Res Council Special Report 235

[2] Kent-Jones (1939) *Modern Cereal Chemistry* Third Edition 46–8

The composition of *products made from triticum durum* flour are given below

	Protein	Fat	Carbo hydrate	Cal cium	Iron	Vitamin B_1	Calories *per lb*
				mg	mg	μg	
Macaroni (raw)[1]	10 7	2 0	69 3	26	1 4	75	1532
" [2]	11 7	2 0	77 0	26	1 43	—	1615
Vermicelli " [3]	12 5	0 8	75 5	—	—	—	1674

The preparations when boiled take up a large amount of water Analyses by McCance and Widdowson [4] give Protein, 3 6, Fat, 0 6, Carbohydrate, 23 7, Calcium, 8 1, Iron 0 45 Calories per lb, 504 so that approximately cooked products have three times as much water as the raw *They are very well digested and* absorbed according to Rubner

There are very many other preparations of wheat on the market, whether from whole wheat, wheat with some of the bran removed or from the endosperm One of the commonest is **Semolina**, prepared from the endosperm of hard wheats It is used in making puddings porridge and for the thickening of soups It contains about 11 per cent of protein Below are given the composition of this and other preparations of wheat

	Protein	Fat	Carbo hydrate	Cal cium	Iron	Vitamin B_1	Calories per lb
				mg	mg	μg	
Processed Bran[5]	10 9	4 2	54 5	98	12 9	—	1355
Germ[5]	32 0	7 7	37 8	58	9 7	2100	1581
Flaked Wheat [5]	13 9	2 3	66 0	34	4 9	40	1542
Puffed [5]	13 7	2 3	66 1	34	4 7	15	1542
Semolina [5]	10 7	1 8	69 8	18	1 0	90	1538
Vita weat [4]	9 4	10 3[6]	68 1	44	3 4	—	1763

[1] *Nutritive Values of War time Foods* (1945) Medical Research Council

[2] *Chemical Composition of Foods* (1942) McCance and Widdowson *Med Res Council Spec Report* 235

[3] Quoted from the *Analyst* (1898) 178

[4] McCance and Widdowson (1942) *op cit*

[5] *Nutritive Values of War time Foods* (1945) Medical Research Council

[6] Evidently fat is added in the manufacture

Shredded wheat is a preparation of whole wheat in the form of shreds or flakes which have been cooked to the consistence of a biscuit, and represents the whole grain in a very digestible form

Force consists of malted whole wheat in the form of flakes, cooked with steam It is easily digested, but not really of higher nutritive value than fine wheaten biscuits (see p 325)

Grape-Nuts is another malted preparation of the entire wheat berry which requires no cooking It contains a high proportion of soluble carbohydrates as well as a considerable amount of protein

Besides these there are many other patent preparations too numerous to mention. It is not unfair to say that these patent foods are a means of selling cheap wheat products at an enhanced price to the public who pay willingly for convenience palatibility and possibly imaginary medical values, what they would not pay for the straightforward virtues of the normal product

ANALYSES [1]

	Protein.	Fat.	Carbo-hydrate	Calcium.	Iron.	Calories per lb.
				mg	mg	
Force	10 2	1 9	75 8	66 3	3 98	1565
Grape nuts	12 8	3·0	71·0	47 8	5 64	1567
Shredded wheat	10 6	2 8	79·0	34 8	4·48	1060

OATS

Oats at first sight appear to be the most nutritious of all cereals They are rich in nitrogenous matter and inorganic substances and are peculiarly rich in fat the only other cereal which can at all compare with them in that respect being maize Carbohydrates are present to the extent of about 73 per cent Further, of the total nitrogenous matter 94 per cent is in the form of proteins two avenalin and gliadin being soluble and avenin, insoluble in water or dilute alcohol The distribution of the amino-acids in the combined proteins shows them to be complete proteins and therefore available for tissue building Unfortunately, the husk of oats is closely adherent and cannot be entirely separated from the kernel so that by the ordinary methods of grinding a good deal of cellulose is left in the meal in the form of small sharp particles These act as

[1] MCCANCE and WIDDOWSON (1942) *op cit*

stimulants to the intestine, and make oatmeal a valuable food where the intestinal movements are sluggish but, on the other hand, are apt to prove rather irritating to some persons

Oatmeal disagrees with some individuals, and dermatitis may develop Horses liberally supplied with oats become excitable They contain calcium magnesium inositol hexaphosphate, the rachitogenic material of cereals in great amount Oatmeal is one of the few vegetable foods which contain some uric acid formers (purine bodies)

There are various ways of preparing oats for human food They may be simply cleaned and ground, the result being *oatmeal* of various degrees of fineness or the branny particles may be separated, and the "oat flour' alone used *Groats* consist of oats from which the husk has been entirely removed, when crushed, Embden groats result

Rolling is now often employed as a method of preparing oats instead of grinding The great pressure to which the grains are subjected between the rollers ruptures the cell walls breaks down the cellulose, and flattens the grains out so that they are more easily softened by cooking By the application of heat during the rolling process, the grains are at the same time partially cooked This not only has the advantage of rendering subsequent preparation for the table considerably less laborious but also alters the fat, which is so abundantly present in oats in such a way that it is less liable to become rancid so preserving the natural flavour of the grain

Quaker Oats" is one of the best known of these preparations ' Waverley Oats' and 'Provost Oats" are Scottish examples The composition of some special preparations of oats is shown in the following table

PREPARATIONS OF OATS

	Scottish Oat meal	Irish Oat meal	Quaker Oats	Scott's Oat Flour	Robinson's Groats.
Water	5 0	5 0	7 8	5 8	10 4
Protein	14 6	13 4	14 7	10 0	11 3
Fat	10 1	8 8	6 2	5 0	6 5
Carbohydrates	65 1	68 4	69 8	77 9	70 4
Cellulose	3 1	1 7			
Inorganic matter	2 1	2 0	1 5	1 3	1 7

More modern analysis of ordinary oatmeal give the following figures

PERCENTAGE COMPOSITION OF OATS

Protein	Fat	Carbohydrate	Calcium	Iron	Phosphorus	Vitamin B_1	Calories per oz
g	g	g	mg	mg	mg	μg	
12 1	8 7	65 5	55	4 1	—	4[illegible]0	110 [1]
13 3	8 7	72 8	55	4 1	380 [2]	—	110 [3]

Oatmeal contains large amounts of potassium (368 mg) magnesium (113 mg) and sulphur (165 mg) per 100 grammes

The composition of some oatmeals when prepared ready for eating is as follows

COMPOSITION OF ROLLED OATS WHEN COOKED [4]

	Water	Protein	Fat	Starch	Cellulose	Mineral Matter
Quaker Oats	92 48	1 65	0 32	6 24	0 09	0 24
Provost Oats	[illegible] 44	2 00	0 36	9 00	0 16	0 24
Mother s Oats	89 72	1 92	0 45	8 70	0 16	0 18
Oatmeal Porridge[3]	89 1	1 5	0 9	8 2	—	—

The enormous amount of water porridge contains will be observed A 7 oz serving of porridge will contain but ¾ oz of oatmeal and supply but 90 Calories The value of porridge at breakfast lies in the additions of cream or milk to it not in its intrinsic properties *In fact because of the difficulty in cooking oatmeal and its low Calorie value for its bulk* porridge is not to be recommended to the working classes

Plasmon Oatmeal made from plasmon and oatmeal originally contained 20 per cent protein and 8 per cent fat During the war of 1939–45 the amount of plasmon added was reduced on account of the difficulty in obtaining milk products It is pre cooked and of very high nutritive value

Owing to the absence of gluten, oatmeal is unfitted for bread

[1] *The Nutritive Values of War time Foods* (1945) Med Res Council

[2] 70 per cent i e 266 milligrammes is phytate phosphorus McCANCE and WIDDOWSON (1942) *Chemical Composition of Foods Med Res Council Special Rep* 235

[3] McCANCE and WIDDOWSON *op cit*

[4] WILLIAMS (1907) *J Amer Chem Soc* 29

making and is usually simply mixed with water and made into cakes By mixing fine oatmeal with an equal quantity of wheat flour, however a fairly good loaf can be obtained A given weight of oatcake (made without butter) contains rather more than twice as much building material as an equal quantity of bread and has almost twice as great a fuel value

Oatmeal requires to be very thoroughly boiled in order to soften the cellulose which it contains "Brose," which is made by merely stirring oatmeal into boiling water, is not a food for delicate stomachs As regards the ***absorbability*** of oats, experiments show[1] that porridge made from rolled oats, even if taken in considerable quantities, is very well absorbed Roughly speaking 95 per cent of its protein 93 per cent of its fat and [illegible] per cent of its carbohydrates enter the blood, whilst 92 per cent of the energy which it yields is 'available' in the body This compares very favourably with the results yielded by bread On purely chemical grounds, oats compare to advantage with wheat as a source of nutriment

Maize (Indian Corn)[2]

Maize is not so largely used as human food in Great Britain as it might be but throughout America it forms a staple article of diet, while in Mexico and South Africa maize is literally the 'staff of life' It was introduced into Ireland at the time of the potato famine in 1848 and has since established a place for itself in the dietary of the people in that country[3]

Chemical analysis shows that maize is quite as nutritious as wheat in all except its inorganic ingredients It is richer in fat than any cereal except oats, containing twice as much of this important constituent as wheat or barley, and three times as much as rye In nitrogenous matter it is slightly inferior to most other cereals but fully 87 per cent of this is in a protein form As regards its digestible carbohydrates it is equal to wheat, but somewhat inferior to barley or rye The average composition of maize products is[4]

[1] U S Dept of Agriculture Bull 101 1901, p 47 (Off of Experiment Stations)

[2] For much practical information on the use of maize as a food see U S Dept of Agriculture's Farmers Bulls Nos 559 and 565 1913 and 1914

[3] For details of the milling of maize see KENT-JONES (1939) *Modern Cereal Chemistry* Third Edition 463

[4] THOMPSON (1917) Report to Food (War) Committee of the Royal Society

	Protein.	Fat.	Starch Sugar etc.	Fibre.	Ash.[1]	Water	Cal per lb
Whole maizemeal unbolted	8.7	4.7	71.1	2.2	1.3	12.0	1690
Whole maizemeal bolted	8.0	4.9	72.0	1.2	1.0	12.0	1765
Maizemeal, granulated (semolina)	9.2	1.9	74.4	1.0	1.0	12.5	1770
Maize flour	7.1	1.3	77.5	0.9	0.6	12.6	1630
Cornflour (corn starch)	—	—	90.0	—	—	—	1675
Flaked maize	9.3	3.48	72.43	1.77	1.18	11.84	1663

Biologically the mixed proteins of maize stand high in the list of values, though zein, one of them, is deficient in tryptophane lysine and cystine Maize contains much calcium magnesium inositol hexaphosphate

The disease pellagra has been in the past associated with the consumption of maize though it may occur when no maize is taken in the diet The dermatitis of pellagra is explained as due to an absence of nicotinic acid from the diet and the nervous symptoms as the result of materials in the germ which antagonize the normal action of vitamin A There is no reason to believe that the consumption of maize induces pellagra so long as the diet is satisfactory as regards its vitamin content

Maize is prepared for food in many different ways In Ireland it is made into a sort of porridge called *stirabout*, or, in the more expressive phraseology of America *mush* In Northern Italy and the South Tyrol it is prepared in a similar way but with the addition of cheese and other ingredients Maizemeal is prepared by grinding after removal of the germ and husk A yellow and a white meal are thus prepared but there is no difference between them as far as nutritive value is concerned except that there is a precursor of vitamin A present in the yellow meal[2] Fine maizemeal is more gritty than wheat flour but when mixed with the latter its presence can hardly be detected The comparative cheapness of maize flour is an inducement to millers to adulterate wheat flour with it, and this has been done to some extent in America Flour so adulterated yields fewer loaves than an equal quantity of pure wheat flour and the bread produced is moister

[1] 363 mg per 100 grammes are phosphorus of which 58 per cent is phytate phosphorus

[2] STEENBOCK BOUTWELL and KENT (1919) *Journ Biol Chem* **41,** xii–xiii

than wheaten bread, and has a tendency to be sodden. An addition of 10 per cent of maize flour is calculated to mean a reduction of five loaves on the sack. Owing to the absence of gluten maizemeal cannot be used to make ordinary bread, but it is often baked into cakes of various sorts. The *johnny* (corruption of 'journey') *cakes* of North America are unleavened, and are made of a rather coarse maizemeal. Similar cakes constitute the *tortilla* of South America. The following is the composition of johnny cakes:[1]

Water	38 0 per cent
Protein	8 5 ,,
Fat	2 7 ,,
Carbohydrates	47 3 ,,
Mineral matter	3 5 ,,

On comparing this with the analysis of good white bread, given on p 322, it will be seen that the comparison is all in favour of maize.

Sometimes the maizemeal is leavened with yeast and subsequently baked in iron vessels. In this form it is known as *pone,* while in Ireland baking powder is used, or the maizemeal is mixed with flour and then converted into loaves. One third of its weight of good flour is sufficient to enable fine maizemeal to form good loaves. The colour of the bread is always rather dark, however, even if the proportion of wheat flour used is increased to one half.

Various *special preparations of maize* deserve mention. *Hominy cerealine* and *samp* are preparations of broken or split maize of various degrees of fineness. The composition of the first two is as follows:

	Hominy[2]	Cerealine[3]
Water	11 9 per cent	10 6 per cent
Protein	8 2 ,,	9 4 ,,
Fat	0 6 ,,	1 0 ,,
Carbohydrates	78 9 ,,	78 6 ,,
Mineral matter	0 4 ,,	0 4 ,,

Both preparations are of high nutritive value and admirably adapted for making puddings, etc.

Cornflour is prepared from maize by washing away the protein and fat by means of dilute alkaline solutions, so that little but starch is left. Modern analysis shows but 0 6 per cent protein (McCance and Widdowson).

These preparations must therefore be regarded simply as agreeable forms of starch, well adapted for food, provided they are taken

[1] Analysis by Atwater and Wood. [2] Analysis by Hutchison.
[3] Analysis by Atwater and Wood

along with some protein and fat carrier, such as eggs or milk but by no means to be recommended on economic grounds

A special small variety of maize is called in America *pop corn* When roasted it swells up and ultimately bursts In this form it is known as popped pop-corn, and is the basis of various sweets [1]

COMPOSITION OF POP-CORN

	Raw	Popped
Water	10 8 per cent	4 3 per cent
Protein	11 2	10 7 ,,
Fat	5 2	5 0 ,,
Carbohydrates	71 4	78 7 ,,
Mineral matter	1 4	1 3 ,,

It is thus a valuable food

Corn Flakes [2] consist of cooked maize which has been treated with malt-honey, dried, rolled and baked It is a nutritious and digestible breakfast food

Corn on the Cob is a special variety of maize, containing much sugar It is cooked while still green, and forms a sweet and succulent ' vegetable ' much esteemed in America It is making its way into Great Britain

Maize is not only a highly nutritive cereal from the chemist s point of view, but has the further advantage of being very well utilized in the human body Experiments show that its carbo hydrates are almost completely absorbed whilst the proteins are only slightly less thoroughly utilized than those of wheat [3]

Nutritive Value of Maize Maize must undoubtedly be regarded as a food of great nutritive value ' With a diet of Indian corn bread and pork says an American writer [4] "the workmen of this country are capable of enduring the greatest fatigue and performing the greatest amount of physical labour

Economic Value of Maize It has been calculated [5] that when maize and wheat are both selling at the same price per bushel one gets the same amount of digestible matter for a given sum in both In wheat however, one gets 2½ lb more protein, and in maize 2½ lb more carbohydrate The fuel value in each case is almost precisely the same

[1] Analysis by Atwater and Wood

[2] Battle Creek Sanitarium Company Ltd

[3] RUBNER (1879) *Zeit f Biolog* 15, 115 Also see U S Dept of Agriculture Farmers Bull (1907) 298

[4] U S Dept of Agriculture Division of Chemistry Bull 50 11

[5] *ibid* 14

Barley

Barley is a grain grown more for the manufacture of malt and for animal fodder than for direct human nutrition The whole grain when ground constitutes barleymeal Scotch barley is the grain stripped of its husk and roughly ground It is chiefly used as human food, however, in the form of either "pearl" or "patent" barley The former consists of the whole grain polished after removal of the husk, the latter is simply pearl barley ground into flour The following is an analysis of pearl barley by McCance and Widdowson

Moisture	10 6 per cent
Protein	8 4 ,,
Fat	1 7 ,,
Carbohydrates	81 3 ,,
Calcium	9 7 mg per cent
Iron	0 67 ,, ,,
Phosphorus	206 0 ,, ,,

It has 120 microgrammes vitamin B_1 (= approx 40 I U) per 100 grammes

Barley contains but little gluten in consequence of which its dough is too "heavy" to make good bread When mixed with half its weight of good wheat flour, however, barleymeal can be converted into good enough loaves

Writing on the nutritive value of barley in 1872, Letheby said "Barleymeal is the chief food of a large number of people in the North of Europe and in the South of England, where the labourer is partly paid his wages in meal or grain It is also used in Wales and Scotland, especially in winter time when wheaten bread is dear, and to some extent in Ireland It is employed by about 90 per cent of the out door labouring population of England At the time of Charles I (1626) according to M Culloch, it was the usual food of the ordinary sort of people and as late as the middle of the last century hardly any wheat was used in the Northern counties of England In Cumberland the principal families used only a small quantity of wheaten bread about Christmas time The crust of the everlasting goose pie, which adorned the table of every county family was invariably made of barleymeal

Since this was written barley has been practically displaced by wheat as an ordinary article of diet and no doubt with considerable nutritive advantage

As an article of diet in the sick room, barley finds its chief use as the main ingredient of *barley water* a preparation which con

tains however but very little nutriment, as the following analysis by Wynter Blyth shows [1]

COMPOSITION OF BARLEY WATER

Water	99 27 per cent
Fat	0 02
Protein	0·03
Starch	0 39
Sugar	0 0.
Inorganic substances	0·03

It is chiefly of value on account of its demulcent properties and makes a pleasant drink with orange or lemon juice

RYE

Next to wheat rye is the great bread making grain of the world It contains no glutelin which will form gluten with the gliadin and as a result of this the bread derived from rye is moist and dense An extreme example is the black bread of North Germany

The composition of the different flours derived from rye varies very considerably with the fineness of milling but fine rye flour is much poorer in protein than flour of a similar grade produced from wheat [2]

Fine rye bread is therefore inferior as building material to wheaten bread, but it is somewhat superior in this respect to bread made from maize

The *digestibility* of fine rye bread is about equal to that of good wheaten bread but the coarser varieties, especially black bread, are very wasteful foods 32 per cent of the protein even in moderately fine rye bread being lost as compared with 20 per cent in white bread In the case of black bread the loss rises to 42 per cent

Swedish crispbread (*Ryvita*) is prepared from crushed whole rye An analysis of it by McCance and Widdowson gave the following composition

Water	5 9 per cent
Protein	7 4
Fat	2 1
Carbohydrates	86 8
Calcium	40 5 mg per cent
Iron	3 73
Phosphorus	295 0

It has a Calorie value of 1696 per lb or 106 per oz

[1] A series of analyses by CORLETTE (*Australasian Med Gazette* 1905 24 1) of barley water prepared from two heaped teaspoonfuls of pearl barley to a pint of water showed that the average amount of starch in the product was 2 03 per cent

[2] KENT-JONES (1939) *Modern Cereal Chemistry* Third Edition 64 and 65

Rice

Rice is the poorest of all cereals in *protein fat* and mineral matter On the other hand it has fully 76 *per cent* of starch The starch has the further advantage of being present in small and easily digested grains When boiled, rice swells up and absorbs a large amount of water, while some of its inorganic constituents are lost by solution It is preferable, therefore, to cook it by steaming

Composition of Boiled Rice [1]

Water	69 9 per cent
Protein	2 3
Fat	0 3 ,,
Carbohydrates	29 6 ,,
Calcium	1 3 mg per cent
Iron	0 16
Phosphorus	34 0

Rice leaves the stomach somewhat slowly $2\frac{1}{2}$ oz cooked by boiling (i e about two thirds of a full soup plate) requiring $3\frac{1}{2}$ hours for its disposal

On the other hand, rice is ***absorbed*** with very great completeness in the intestine, indeed, its solid constituents enter the blood almost as completely as those of meat This is to be attributed to the *comparative absence of cellulose* *Practically none of the starch* is lost, but the waste of protein amounts to 19 per cent [2] It follows from this that rice is one of the foods which leave the smallest residue in the intestine and this gives it a considerable value in some cases of disease

Extensive investigations into the use of rice of different degrees of milling have shown that the digestibility and utilization of rice are always better when the grades of polishing are raised For example, 97 per cent of the energy theoretically available was *utilized when the rice was fully polished*, when unpolished only 90 per cent [3] Rice contains about as much phytates as wheat

The ***nutritive value*** of rice is much impaired by its poverty in protein and fat Hence it is not adapted to be an exclusive diet but should be eaten along with other substances rich in these two elements, such as eggs, cheese or milk It is interesting to note that in some countries in which rice is largely used as a daily food this is actually done as in the Italian *Risotto* the Turkish *Pilaff* and the Spanish *Pollo con Riz* Even as regards carbohydrate it would require about 1 lb 3 oz of rice to furnish the daily need of

[1] Analysis by McCance and Widdowson (1942) *op cit*

[2] Kumagawa (1889) *Virchow's Archiv* 116, 370

[3] Tadasu Saiki (1926) *Progress of the Science of Nutrition in Japan* Publications of the League of Nations III Health 3, 25

an active man This would entail the consumption of about 5 lb of cooked rice daily It is worth observing, too that in Eastern countries in which rice takes the place of bread it is eaten in a much drier, and therefore more concentrated form than it is in Europe and with the addition of various sauces and condiments to give it flavour and promote its digestion

The association of disease with the consumption of large amounts of a highly milled cereal has its classical illustration in highly milled rice Where polished rice (i e rice with the bran, the embryo and the silverskin removed) is the staple food there beri beri appears In the very poorest classes in the Far East who cannot afford the highly milled rice beri beri is rare while beri beri can be prevented or cured by extracts of rice bran There is an intermediate method of processing rice in which it is first parboiled and then the bran removed In this process some of the antineuritic principles probably in the main vitamin B¹ migrates into the endosperm—sufficient to prevent the appearance of beri beri when this product is the main food eaten

In the poorly nourished parts of the world where rice is the staple food this is of immense importance and as an interim measure the retention of the antineuritic principles in the rice eater should if possible be made compulsory The long term policy however, should be to promote a higher standard of living In countries where rice forms but a small part of the diet as it does in temperate climates the amount of milling appears to be of little importance

Millet and Buckwheat

These cereals [1] are not used as human food in this country, although they are by no means of low nutritive value but stand midway in that respect between wheat on the one hand and rice on the other Millet is freely consumed in Africa being the staple diet of the negroes of the Upper Nile, and in some Southern European countries while in China it is used to make bread The dhoora (sorgho grass) or Indian *millet* is of very similar composition The following is an analysis of it given by Church

Composition of Millet

Water	12 2	per cent
Protein	8 2	"
Fat	4 2	
Carbohydrates	70 6	
Cellulose	3 1	
Inorganic substances	1 7	

[1] Buckwheat is not strictly a cereal but belongs to the Polygonaceæ It is considered here for convenience

Buckwheat is about equal in nutritive value to millet, but contains much more cellulose (10 per cent) It is usually eaten in the form of a porridge or fritters In this country, though pleasant, it is hardly ever used as human food, but it is freely consumed in Brittany and Holland and in some parts of the United States

The published analyses of buckwheat are somewhat discordant Four are here given

COMPOSITION OF BUCKWHEAT

	Church [1] (grain husked)	Leyden [2] (flour)	Atwater and Bryant [3] (flour)	Plimmer [4] (grain)
Water	13 4	14 2	13 6	12 6
Protein	15 2	9 2	6 4	12 1
Fat	3 4	1 8	1 2	1 9
Carbohydrate	63 6	73 3	77 6	62 3
Fibre	2 1	0 8	0 4	8 9
Inorganic substances	2 3	1 2	0 9	2 2

The Pulses

In this group are included peas, beans and lentils and their allies The edible parts of these resemble the grain of cereals in that they are to be regarded as storehouses of food materials for the young plant Though regarded as vegetables' i e things to serve with the joint they are really more valuable as sources of (i) energy and (ii) protein so that physiologically they belong to this and the next section of this book They do also supply vitamins of the B complex iron and some calcium and phosphorus Their defects are (i) that they contain no fat (with the exception of the soya bean) and (ii) on cooking they take up so much water that they are a bulky food The proteins in the pulses vary in nature slightly according to their origin They are mainly globulins being insoluble in water, but water soluble albumins are present The globulins of pulses are distinguished by having more glutamic acid in their molecules than animal globulins but distinctly less than the main proteins of the cereals Their content of the sulphur containing amino acids is low, while arginine is often high in amount The proteins of the pulses are very satisfactory sources of phenylalanine arginine histidine, and lysine moderate as regards cystine and tyrosine while trytophane is present [5] Their biological value which is increased by cooking ranks below that of the cereals [6]

[1] *Food* (1898) Chapman and Hall London 93
[2] Leyden s *Handbuch der Ernahrungs Therapie* (1903) 2nd edn 1, 99
[3] ATWATER and BRYANT (1906) U S Dept of Agriculture Bull 28
[4] PLIMMER (1921) *Analyses and Energy values of Foods*
[5] OSBORNE (1924) *The Vegetable Proteins* Longmans Green & Co
[6] BOAS FIXSEN (1934–5) *Nutr Abstr* 4, 447

The pulses are well supplied with carbohydrates but because of their lack of fat go well with fatty foods (e g bacon and beans pork and pease pudding), and are improved by being served with sauces containing butter or cooked with oil They also possess a bitter principle which renders them unpalatable to many persons Dried peas and beans require prolonged soaking in order to soften their skins Even haricots in which the skin is comparatively thin require about eight hours to soften The water in which they are soaked should contain a small amount of soda but not so much as to destroy their vitamin B_1 A negligible amount of protein and sugar is lost by this soaking which however has the advantage of removing most of the bitter principle in the seeds The amount of water taken up is very great The proportion of water in dried haricot beans for example rises as the result of soaking and boiling from 14 per cent up to 73 per cent, and in the case of peas the increase is from 9 7 up to 86 0 per cent [1] This increase in water entails a corresponding increase in the weight and bulk of the food and must always be taken into account when comparing the relative nutritive values of the pulses and meat

The pulses are ***not readily digested*** by the stomach As Galen said 'They are harder to digest than other foods and give bad dreams' This is no doubt partly owing to their bulkiness when cooked Thus after 5½ oz (150 grammes) of lentils in the form of a mash or about a soup plateful had been eaten the stomach was not completely empty in 4 hours and after 200 grammes of peas in a similar form in 4½ hours An equal weight of French beans (*haricots verts*) remained rather longer even than that

If properly prepared the pulses are ***absorbed*** in the intestine very thoroughly Thus the protein of pea or lentil flour is all taken up except about 8 or 9 per cent [2] when 200 grammes (7 oz) are given daily Even when the amount given was as much as 600 grammes (21½ oz) the loss was only as follows [3]

Dry substance	9 1 per cent
Protein	17 5
Carbohydrate	3 6
Inorganic material	32 5

This shows that the protein of the pulses, if given in a state of fine division, is capable of very good absorption On the other

[1] Analyses by WILLIAMS (1892) *Journ of Chem Soc* 61 226 1 oz of peas take up approximately 2 oz of water MCCANCE and WIDDOWSON (1942) *Med Res Council Report* No 235

[2] STRÜMPELL (1876) *Deut Archiv f Klin Med* 17 108

[3] RUBNER (1880) *Zeit f Biolog* 16 119

hand, the loss is very much greater if the food is not given in a state of fine division It was found, for example that if the lentils were simply boiled soft and taken along with broth, the loss of protein rose to 40 per cent It will be noted that there was a small loss of carbohydrate even on pea flour The amount of it however, is less than from potatoes or carrots but more than that from white bread

Extensive investigations on the absorption of different forms of legumes have been made in America [1] They showed an average absorption of 80 per cent of the protein and 97 per cent of the carbohydrates These results are very favourable when it is remembered that the legumes constituted the major part of the diet in the subjects studied

The nutritive value of the pulses is undoubtedly high They yield about 1500 Calories per lb (94 per oz) and they have considerable value as sources of protein although the comparative deficiency of the protein in sulphur containing amino acids probably lessens its value as a source of building material It would require about 400 grammes (14 oz) of pea flour to supply the amount of protein required daily for an active man Suppose this were to b given in the form of pea soup A good thick soup would contai 16 grammes—a level tablespoonful—in each plate The protei value of this would be equal to less than an ounce of meat Twenty five platefuls of such a soup then would require to be taken in th day By making the soup with milk instead of water—an excellen plan—the amount of protein in it would be trebled and eigh platefuls would suffice

The 400 grammes of pea flour would hardly, however, contain as much carbohydrate as is required, and would be very deficient in fat These deficiencies would have to be made good by the addition of some other articles to the diet, or by increasing the amount of pea flour consumed As a matter of fact, it has been found that when the quantity of peas eaten amounts to 960 grammes (34½ oz) in the 24 hours all the demands of nutrition as regards Calories and protein are satisfied, [2] but it is very doubtful whether anyone could go on consuming this quantity for any length of time I comes then to this, that, while the pulses are most valuable sources of Calories and protein they are not adapted to be the exclusive diet of health As a cheap and efficient method of supplementing the deficiency of nitrogen in a purely vegetable diet however their use is strongly to be recommended, and it is a pity that

[1] *Studies on the Digestibility and Nutritive Value of Legumes* (1907) U S Dept of Agriculture Bull 187

[2] Rubner *loc cit*

Composition of Pulses[1]

	Protein	Available Carbohydrate	Unavailable Carbohydrate	Calories	Milligrammes per 100 grammes							
					Na	K	Ca.	Mg	Fe	Cu.	P	S
		Per cent	Per cent	Per 100 grammes								
Beans butter raw	19.2	49.8	24.5	266	61.5	1700	84.8	164.0	5.92	1.22	318.0	100
boiled	7.1	17.1	5.1	93	16.2	398	18.7	33.3	1.67	0.16	86.5	[illegible]
haricot raw	21.4	45.5	28.8	258	43.2	1160	180.0	183.0	6.65	0.61	309.0	166
boiled	6.6	16.6	7.4	89	15.0	320	64.5	44.5	[illegible]	0.14	122.0	46.3
runner raw	1.1	2.9	3.0	15	6.5	276	33.3	23.0	0.74	0.09	25.9	14.1
boiled	0.8	0.9	3.0	7	3.3	87	25.6	12.5	0.59	0.03	10.7	9.5
Lentils raw	23.8	53.2	17.4	297	36.0	673	38.6	76.5	7.62	0.58	242.0	[illegible]
boiled	6.8	18.3	2.4	[illegible]	9.4	217	10.5	20.7	2.20	0.27	80.0	37.3
Peas raw fresh	5.8	10.6	5.2	64	0.5	342	15.1	30.2	1.88	0.23	104.0	[illegible]
boiled fresh	5.0	7.7	5.2	49	Tr	174	12.6	21.4	1.22	0.15	83.3	43.5
dried raw	21.5	50.0	21.3	[illegible]	37.9	985	60.8	116.0	4.73	0.49	303.0	120
boiled	6.9	19.1	4.8	100	12.6	267	24.4	30.3	1.44	0.17	113.0	39
split dried raw	22.1	56.6	17.2	303	38.3	910	33.0	123.0	5.40	0.58	268.0	166
dried boiled	8.3	21.9	5.1	116	14.2	269	10.8	30.2	1.74	0.23	122.0	45.7
tinned	5.9	16.5	4.4	[illegible]	(260)	201	25.7	24.4	1.87	0.21	109.0	43.9

[1] McCance and Widdowson (1942), *Med Res Council Special Report* No 235

they are not more largely taken advantage of by those to whom economy is of importance for unquestionably the pulses are amongst the cheapest foods, and a given sum will yield more protein if invested in them, than in any other way It remains to add a few words about the individual members of the pulse group Their chemical composition is shown in the table on page 345

The *garden pea* (Pisum sativum) is eaten either fresh (green peas) or dried Green peas cooked in the usual way contain about 8 per cent of carbohydrate, of which a considerable proportion is sugar *Of beans* there are several edible varieties The French or kidney bean (Phaseolus vulgaris) is eaten either in the young state along with the pod (*haricots verts*) or the seeds are consumed alone either fresh or after drying (*haricots blancs*) The amount of cellulose in the pod causes it to be digested and absorbed with difficulty, and on that account it is a wasteful form of food Allied to the French bean is the scarlet runner (Phaseolus multiflorus) the dried seed of which when stewed constitutes Turkish beans The *broad* or *Windsor bean* (Faba vulgaris) is eaten either in the fresh or dry state It is a frequent cause of allergy when eaten in large amounts [1] A coarser variety of the same plant is the horse or field bean It is not usually consumed as human food.

The *Lentil* (Lens esculenta) is even richer in protein than either the pea or the bean and as a rule the smaller varieties of it are richer in that constituent than the larger Egyptian lentils are amongst the best Lentils contain little sulphur and are more digestible and less apt to cause flatulence than either peas or beans The ash of the Egyptian lentil is particularly rich in iron

The *Soya Bean* (*Glycine hispida*) is one of the pulses which has sprung into remarkable prominence in this country and elsewhere during the second World War, though it has been used for many centuries—as early as 3000 B C—in China Its present vogue is due partly to the belief that it formed the basis of the iron rations of Hitler s Blitzkrieg soldiers and partly to the activities of the Ford automobile company According to Sir John Russell of Rothamstead it cannot be satisfactorily grown in the uncertain climate of Great Britain even if the rapidly ripening varieties developed for cultivation in Manitoba be utilized It needs a hot dry summer Its original source is Manchuria but it is now successfully grown in central Europe the U S A and Canada and in the Dutch East Indies

It is remarkable among the pulses in its high content of protein (29 to 50 per cent) its fat (13 [illegible] to 24 per cent) and the replacement of starch by dextrins (4 65 to 8 97 per cent) and by sugars [illegible] 65–9 46

[1] *Lancet* (1941) 2, 164

per cent) On account of the absence of starch it has been mistakenly used as a substitute for bread in diabetes

In China and Japan it is extensively eaten in the form of soya cheese and in various sauces and pastes all of which are rich in protein and therefore fitted to supplement the deficiencies of rice It has also been used for centuries by millions of people in the Far East in place of cow s milk and it can in part replace milk in diet of infants[1] Aykroyd[2] in experiments on the growth of mission school children in India has found that soya bean is disappointing Addition of it to the standard diet caused no increase of growth rate whereas skimmed milk powders produced a marked improvement Consequently the claims made for the nutritional advantages of a soya bean diet must be discounted

There is a preparation of soya bean on the market from which the unpleasant beany flavour has been removed This is Soyolk[3] It is intended for mixture with ordinary flour in the making of scones buns pastry and bread, for which purpose it is excellent giving a brown glazed appearance which is much prized It has 44 per cent of protein 20 6 per cent of fat and 25 per cent of carbohydrates Its percentage of calcium (0 3) is more than double that of milk

Soya bean has for long been used as a filling for sausages pre eminently so in this country during the later years of the second World War Dried soya bean milk forms the basis of a food beverage called Vitone

The *Peanut* (Arachis hypogæa) although botanically one of the pulses really resembles more closely the true nuts Like these it is rich in proteins and fat containing about 25 per cent protein and 48 to 54 per cent fat Its carbohydrates are only 11 per cent From the distribution of the amino acids in the two main proteins arachin and conarachin they should have a good biological value[4] The fat expressed from the nut is used in the manufacture of margarine

Peanuts are not an important item of diet in this country though they are eaten largely in the United States and Canada either roasted or in the form of peanut butter a comestible which has made its way into Great Britain during recent years Agriculturally the pea nut crop is becoming one of the most important crops of the world

[1] RITTINGER (1935) *Journ of Ped* 6 517 MACKAY (1940) *Arch Dis Childh* 15

[2] AYKROYD and KRISHNAN (1937) *Ind J med Res* 24 1093

[3] The Soya Flour Manufacturing Co Ltd Rickmansworth

[4] TRAILL (1945) *Chem and Ind* 58

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[1] *Lancet* (1941) 2

Nuts

From their analyses given on p 318 it appears that nuts are a valuable form of diet With the exception of the chestnut they have a high Calorie value approaching or exceeding that of cheese and bacon a high protein value with the exception of chestnut cob nuts and coco nuts the calcium values of almonds barcelonas and brazils are high but partly offset by their phytate phosphorus and they unexpectedly possess vitamin C though this may have been over-estimated

But in dietetics at any rate in the British Isles their contribution to the diet is almost negligible This may be due to lack of fashion demand except among vegetarians to the large amount of waste as purchased (except in the chestnut) and to their reputed indigestibility

This indigestibility is due in part to their richness in fat and to their compact framework of cellulose By thorough mastication this difficulty can be overcome to some extent but is still more efficiently dealt with by artificial grinding and cooking Various preparations are on the market and can be found in shops which supply vegetarians The fibrous nature of nuts irritates the pharynx and consumptives and others with respiratory diseases should avoid them

A few experiments have been made on the ***absorbability*** of nuts In one which was carried out in America [1] and in which the subject of experiment lived solely on a diet of fruit and nuts it was found that 82 5 per cent of the protein [2] 86 9 per cent of the fat and 90 per cent of the non nitrogenous matters were absorbed This result compares favourably with the absorption of an ordinary mixed diet except that it reveals a rather greater waste of protein and shows that it is quite possible for long periods even to supply the requisite protein and energy from a diet made up of selected fruits and nuts Fine division greatly aids their digestibility

Of all the members of this class of foods the ***chestnut*** is probably of the greatest general value as an article of diet It is peculiar amongst nuts in containing a high proportion of carbohydrates along with a fair amount of protein and fat as is shown on

[1] *Nutrition Investigations among Fruitarians and Chinese* U S Dept of Agriculture (1901) Bull No 107 For later experiments which however yielded substantially the same results see *Nuts and their Uses as Foods* (1908) Farmers Bull No 332 also CAJORI (1918) *Journ Home Econ* 10 304

[2] So far as it has been investigated the biological value of nut proteins is low even below that of legumes BOAS FIXSEN (1934–5) *Nut Abs* 4 447

COMPOSITION OF NUTS (EDIBLE PORTION) [1]

	Grammes per 100 grammes			Milligrammes per 100 grammes									Vitamins I U per 100 grammes			Calories per oz
	Protein	Fat	Available Carbohydrate	Na	K	Ca	Mg	Fe	Cu	P	Available P	Cl	A	B_1	C	
Almonds	20 5	53 5	3 9	5 8	856	247	257	4 23	0 14	442	78	1 7	—	80	0–386	151
Barcelona	12 9	64 0	4 7	2 5	935	170	202	2 97	0 96	299	49	33 5	—	—	—	183
Brazil	13 8	61 5	3 7	1 5	760	176	411	2 [illegible]	1 10	592	82	61 0	—	—	—	177
Chestnut	2 3	2 7	32 9	10 9	497	46	33	0 89	0 23	74	65	15 0	—	90	646	47
Cob nut	9 0	36 0	6 1	1 4	345	44	[illegible]	1 06	0 21	229	59	5 9	—	200	300	109
Coco nut	3 8	36 0	3 3	16 5	436	13	52	2 08	0 32	94	19	114 0	—	trace	16	100
Peanut	28 1	49 0	7 7	5 6	680	61	181	2 04	0 27	385	145	6 8	63	100	—	168
Walnut	12 5	51 5	4 5	2 7	687	61	131	2 35	0 31	510	298	23 0	—	150	600	151

[1] Chemical Analyses by McCANCE and WIDDOWSON (1942) *Med Res Council Report* No 235 Vitamin figures from FIXSEN and ROSCOE (1937–8) *Nut Abs and Rev* 7 823

cultivated mainly as a curiosity, in Europe near Seville in 1572 Its introduction into England in 1586 is attributed to Sir Walter Raleigh [1] *To-day scientific agriculturists have returned to Peru* to obtain material for breeding experiments and so evolve potatoes resistant to disease and frost Although introduced so long ago it took two centuries for its use to become at all common Ireland *was the country where it first became popular and such an exclusive* hold had it in the dietary of the Irish that potato disease rampant in the years 1845 to 1847 caused famine in that country and led to the repeal of the Corn Laws in Great Britain

If a raw potato be cut across with a sharp knife three distinct *layers* can easily be made out (Fig 16) These are (1) the thin outer skin (2) A broader layer inside the skin called the fibro-vascular layer" It contains a small amount of pigment and turns green when exposed to the light This was supposed on inadequate evidence to make the potato poisonous (3) The flesh of the potato which makes up the rest of its bulk On more careful inspection this is seen to be divided into a central core and an outer zone which surrounds it

These different layers form the following proportions of the whole potato

1 Outer rind	= 2½ per cent
2 Fibro vascular layer	= 8½
3 Flesh	= 89

The importance of recognizing them is due to the fact that they differ somewhat in chemical composition as is shown in the following table [2]

COMPOSITION OF A POTATO

	Water	Nitrogen As Protein	Nitrogen Total	Fat	Carbo hydrate	Ash
Outer rind	80 1	0 25	0 43	0·8	14 6	1 8
Fibro vascular layer	83 2	0·24	0 36	0 1	13 3	1 1
Flesh	81 1	0 18	0 32	0 1	16 0	0 8
Whole potato	81 3	0 19	0 32	0 1	15 7	0 9

The fibro vascular layer is seen to be richer in inorganic matter and protein than the flesh and in peeling it off with the rind we lose these ingredients

If the flesh of the potato is squeezed it can be separated into a solid part and a juice The former consists mainly of starch it has *only 15 per cent of the nitrogenous matter* The juice consists of water holding in solution nitrogenous matter and salts It con

[1] LINNÉ (1939) *Nature* 143 10 In a review of Salaman's work.
[2] See U S Dept of Agriculture (1897) Bull 43

p 348 Roasted chestnuts have 40 per cent water Those cooked by boiling have 72 per cent

An economic point in favour of chestnuts also is the fact that a given area of ground produces perhaps the maximum amount of human food when planted with chestnut trees

The great value of the chestnut has been fully recognized by the poorer peasantry of Central France During the autumn and winter they often make two meals a day from it alone The nuts are prepared by removing the outside shell, blanching and then steaming, salt and milk are added when they are eaten Sometimes they are ground after blanching, and the meal made into flat cakes

The ***almond*** is another very valuable form of nut being specially noteworthy for the large amount of nitrogenous matter which it contains It has the further advantage of being compact and portable "No man " it has been said " need starve on a journey who can fill his waistcoat pocket with almonds "

From the graphic representation of a typical nut, the walnut, and from the tables it will be observed that fatty matter predominates very largely in the composition of nuts with the exception of the chestnut No other vegetable substance is so rich in fats Advantage has been taken of this to prepare from nuts various fatty preparations which are used as cheap and efficient ***substitutes for ordinary butter*** in the kitchen Advertisements of these will be found in the vegetarian magazines There is every reason to believe that these are equal in fuel value to ordinary butter whilst they are decidedly more economical The fat of the coco nut is used in the manufacture of margarine

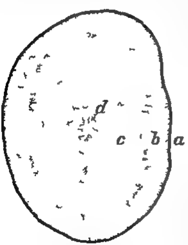

FIG 16—CROSS SECTION OF A POTATO

a Skin *b* Fibro-vascular layer *c* Outer zone of flesh *d* Central core

The Potato

Next to maize the potato is the most valuable food contributed by the western hemisphere to the Old World In fact to Europe it is the most important contribution made and the varieties evolved from the original source are legion The potato is the swollen underground stem of the potato plant in which it stores its nutriment for use of the young plant

The potato originated probably in Peru or Bolivia and was first

can be largely obviated by boiling in their jackets does not matter There is a loss of one quarter to one third of vitamin C on boiling [1] and of one quarter of the vitamin B_1 [2] However, 4½ to 5½ oz of boiled new potatoes give 30 milligrammes of ascorbic acid—a day s ration—so that the loss is not very important Boiled old potatoes yield 0 3 I U of vitamin B_1 per gramme More would be con served were they boiled in their jackets

Mention of vitamin C recalls the fact that shortage of potatoes due to disease or other causes is followed invariably by outbreaks of scurvy, so that it is probable that the potato is the main source of vitamin C in the British diet As the majority of potatoes contain anything from 10 to 53 milligrammes of vitamin C per 100 grammes (3½ oz) and the average person consumes up to 8 oz per day it will be seen that even with the loss that occurs on boiling a large quantity of vitamin C will be taken every day From March onwards the old potato contains only 7 milligrammes per 100 grammes [3] Steaming, keeping them warm for a long time reheating them cooking them in a haybox i e fireless cooker' result in much greater destruction so that no one living much in hotels or public institutions or feeding in restaurants should trust the cooked potato as an adequate source of vitamin C

The composition of fried and roast potatoes is as follows [4]

	Gm per 100 g			mg per 100 g							
	Protein.	Fat.	Available Carbohydrate	Na.	K.	Ca	Mg	Fe	Cu.	P	Cl.
Fried	3 8	9·0	37 3	mg 11 7	1020	13 8	43 3	1 35	0·27	7	140·0
Roast	2 8	[illegible]	27 3	8 6	745	10·1	3 0	0·99	[illegible]	53·0	103 0

The *digestibility of potatoes* in the mouth and stomach depends largely on the form in which they are eaten They are less digest ible when eaten as lumps than in a purée and mealy potatoes are more digestible than waxy or new potatoes

Two medium sized potatoes (weighing together 5½ oz) when boiled and eaten in the usual way remain for about 2 to 2½ hours in the stomach—that is a shorter time than a similar weight of bread

[1] OLLIVER (1936) *Chem and Ind* 55 153T
[2] BAKER and WRIGHT (1935) *Biochem Journ* 29 1802
[3] *The Nutritive Values of War time Foods* (194_)
[4] McCANCE and WIDDOWSON (1942) *Med Res Council Rep* No 23_

tains fully 85 per cent of the total amount of nitrogenous matter present in the potato

It must be clearly realized that by no means all of this nitrogenous matter is present in the form of protein Of the total amount of nitrogen in a potato only 37 to 64 per cent is contained in proteins the remainder being simple nitrogenous bodies such as asparagine glutamine arginine and choline [1] The failure to recognize this fact has led people to assume that the whole of the nitrogen of the potato represents protein, and to overrate the value of potatoes as tissue building food

The richness of the potato in starch is its most striking chemical characteristic and causes it to be one of the chief commercial sources of that substance Dextrin and " British arrowroot " and many other things are prepared from it The starch grain of the potato is of specially large size, but unless cooked it is not easily digested and absorbed by the body and it causes much flatulence [2] Owing to their readiness to undergo fermentation potatoes should be avoided in conditions such as dilatation of the stomach

The most important inorganic ingredients of potatoes are potassium salts and potatoes are one of the chief sources from which we obtain our supply of these salts Part of the potassium is united with citric acid Potatoes, like all tubers, may have their composition modified by the *mode in which they are cooked*

Plain boiling removes some nitrogenous and inorganic materials but leaves the starch practically unaltered as the following figures show [3]

	Gms per 100 grammes		Mg per 100 grammes							
	Protein	Available Carbohydrate	Na	K	Ca	Mg	Fe	Cu	P	Cl
Potatoes old raw	2 1	0 8	6 5	568	7 7	24	0 75	0·15	40 3	78 6
old peeled and boiled 30 mins	1 4	19 7	3 4	3 5	4 3	15 0	0·49	0·11	[illegible]9 0	40 7

As we eat potatoes mainly for their carbohydrate and not for their nitrogen potassium and chlorides the loss in these materials, which

[1] NEUBERGER and SANGER (1942) *Biochem Journ* 36, 665

[2] LANGWORTHY and MERRILL (1924) U S Dept of Agriculture Bull 1213

[3] MCCANCE and WIDDOWSON (1942) *Med Res Council Rep* No 235

of the tuber is inulin mainly, and as such indigestible Even assuming that half the carbohydrate is available the artichoke contains but 3 2 per cent against the potato s 20 per cent One pound of boiled artichokes yield 86 Calories to the body whereas potatoes yield at least 360 The suggestion of replacing potatoes by artichokes is dietetically ludicrous Besides that they are intensely disliked in the kitchen and on the table It must be again emphasized that despite their other valuable characteristics, potatoes are taken mainly for their Calories and indeed are often associated with the cereals as the main sources of Calories [1]

Allied to the potato, though not much eaten in this country, are the sweet potato and the yam

The *Sweet Potato* (Ipomœa batatas) is cultivated in hot countries, and is largely eaten in the United States It used to be eaten in England before the present potato was introduced, and it is to it that Shakespeare refers when he makes Falstaff say, ' Let the sky rain potatoes ! " It contains carotene the precursor of vitamin A

The *Yam* is the tuber of a tropical plant Dioscorea, and is much larger than the potato but resembles it in taste

The composition of the sweet potato and yam is as follows

	Protein	Fat	Carbohydrate	Ash
Sweet Potato	1 6	0 5	22 5	0 7
Yam	2 2	0 5	15 3	1 5

They are fully equal to the ordinary potato in nutritive value

Arrowroot Sago and Tapioca

These substances which consist of little more than starch and dextrins and are used in this country only as a basis for puddings etc must be considered under the heading of foods taken for Calories because in some parts of the world they bulk largely in the diet and are used where we should use cereals

Modern analyses give the following compositions

	Protein	Fat	Carbohydrate	Calcium	Iron	Phosphorus	Calories per oz	Vitamins A B C
				mg	mg	mg		
Arrowroot	0 4	0 1	90 6	7 0	1 95	27	97	0
Sago	0 3	0 2	94 0	9 8	1 18	29	101	0
Tapioca	0 4	0 1	95 0	8 2	0 32	30	102	0

It will be seen from this table that these foods are almost useless except for Calories Of these they give as much as cereals and indeed are usually classified with the cereals though this is unwise

[1] Le Gros Clark (1943) *Discovery* July

In the intestine potatoes are, on the whole, very well *absorbed* This is owing to the fact that they contain much starch and little cellulose Even when the quantity consumed daily amounts to 3½ lb 92½ per cent of the starch and 70 per cent of the total nitrogen enters the blood

Potatoes are, however, by no means suited to constitute the sole or even the staple, diet of man They are much too bulky, and contain too little protein in proportion to their starch As a matter of fact, however, Rubner has found that 6½ lb of potatoes are enough to furnish 3003 Calories of energy and to prevent any loss of bodily protein This is probably to be explained by the relatively enormous quantity of carbohydrates (i e protein sparers) which such a diet contains [1] Hindhede obtained even better results, and is a strong advocate of the potato as an efficient and economical source even of protein [2]

Even granting that 6 lb of potatoes per day is sufficient to supply fully all the needs of the body, it must be evident that this quantity is still unduly bulky, weighing as it does about twice as much as an ordinary mixed diet The result of its continued use would be an undue burdening of the stomach and bowels culminating in dilatation, if not disease, of these organs The so called "potato belly" of the Irish peasant is an example of such a result

As regards *economic value* potatoes must be regarded as a cheap but by no means the cheapest kind of food Thus, when potatoes are selling at 1*d* and bread at 1½*d* per lb the former are two or three times dearer than the latter From the point of view of national economy, however, potatoes are undoubtedly a cheap food Thus, Boussingault found that a given piece of land produces

	Wheat	Rye	Peas	Potatoes
Protein	510	440	560	950
Starch	1590	1196	780	6840
Ash	90	62	60	323

Whenever there is an emergency need for more home grown Calories as there has been in this country during the second World War correspondents write to *The Times* urging the pre eminence of the *Jerusalem artichoke* over the potato pointing out that this tuber produces weight for weight more return per acre than the potato This is true But when investigated dietetically the case for the artichoke breaks down The carbohydrate storage product

[1] There is some evidence that the nitrogenous constituents of potatoes are nearly twice as valuable for the repair of tissues as those of bread

[2] (1926) *The Practitioner*, 116 249

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ARROWROOT SAGO AND TAPIOCA

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[1] LE GROS CLARK (1943) *Discovery* July

It is not to be expected that nations who live largely on any one of these foods could attain the physique of those living on rice or other cereals

Arrowroot is obtained from the rhizome of a West Indian plant (Maranta arundinacea) The roots are mashed up mixed with water, and the starch allowed to settle When dried it constitutes ordinary arrowroot The superiority of *Bermuda arrowroot* to the other varieties is due to greater care in manufacture The starch, having been washed away from the mashed roots and strained through muslin is allowed to settle, and is subsequently dried in flat copper pans covered with gauze When dry, it is packed by means of German silver shovels into new barrels lined with paper stuck in with arrowroot paste *All these precautions are necessary to prevent the arrowroot from becoming contaminated* as it is so apt to be, by foreign flavours For a similar reason it is exported on deck under covers lest it may be affected by effluvia from the cargo in the hold

Arrowroot contains 11 per cent of water and 90 per cent of starch dextrins and sugar estimated as glucose along with only about 0 4 per cent of protein and 0 7 per cent of ash

The *digestibility of arrowroot* and its allies in the stomach is probably high and their absorption in the intestine is exceedingly complete This gives them a special value in the treatment of diarrhœa

Sago is derived from the pith of the sago palm The trees are felled, split, and the starch washed out It is then dried and converted into pearl sago by granulating *One tree should yield about 500 pounds of sago Commercial sago contains 94 per cent of starch*

Tapioca *is derived from the roots of* South American cassavas, plants belonging to the Spurge order (Euphorbiaceæ) Curiously enough, one of these—the bitter cassava (Manihot utilissima)—contains a milky juice mixed with the starch in which there is a good deal of that dangerous poison hydrocyanic (prussic) acid [1] In preparing tapioca the juice is washed away from the grated root and the starch allowed to settle It is then collected and dried on hot metal plates The process of drying has the effect of rupturing most of the starch grains Tapioca as found in the market contains about 11 per cent of water and 85 5 per cent of carbohydrate and has a fuel value of 1578 Calories per pound *Pure starch contains only 2 per cent of water and a pound of it furnishes 1825 Calories so that weight for weight* pure starch gives considerably more Calories than tapioca

[1] This gives an amusing counter to food cranks who say that we should eat the foods nature supplies us in their natural *condition*.

Tapioca remains longer than might be expected in the stomach Forty grammes of it in the form of a thick gruel (about a soup plateful) had not entirely left the stomach until after the lapse of two hours and forty minutes (Penzoldt) There is reason to believe that it is absorbed very completely in the intestine

As regards the *nutritive value* of all these preparations, it must be remembered that they are simply agreeable forms of starch, in other words, they consist almost entirely of carbohydrate and should therefore not be eaten alone, but along with substances rich in protein, fat and vitamins Eggs and milk are typical examples of such substances, and accordingly one finds that people have made puddings of arrowroot, sago, or tapioca along with milk and eggs before anything was known of the chemical constituents of the diet Tapioca pudding has something like the following composition [1]

Water	71 7 per cent
Protein	3 2
Fat	3 8
Carbohydrates	21 4
Calcium	0 116
Iron	0 0098
Phosphorus	0 095

and has a fuel value of about 128 Calories per serving ($3\frac{1}{2}$ oz) It must be regarded as a highly nutritious food

A cupful of *water-arrowroot* contains only about 2 grammes of starch It would furnish to the body about 9 Calories of fuel value while even an invalid requires about 2000 Calories daily

When one considers the *economy* of these different preparations one may say that sago and tapioca are worth the price paid for them while the better qualities of arrowroot certainly are not Starch at $4\frac{1}{2}d$ a pound is really rather dearer than tapioca at $3\frac{1}{2}d$ or sago at $3d$ even although it contains 10 per cent more nutriment Apart altogether from that also one cannot eat pure starch, whereas the same chemical substance in the form of tapioca or sago is quite agreeable On the other hand Bermuda arrowroot at $7s$ $3d$ the pound is a purely luxury article The cheaper kinds at $9\frac{1}{2}d$ are quite as nutritious, and there can be no physiological objection to the substitution for a genuine article of the so called *Farina* or *English arrowroot* prepared from the starch of maize or potatoes at $3\frac{1}{2}d$ per lb Even although it requires more of these to make a jelly than of the genuine arrowroot yet this difference is far more than made up for by the difference in price

[1] McCance and Widdowson (1942) *Med Res Counc Spec Rep* 235 The protein fat and calcium are added by the milk

CHAPTER XIII

FOODS TAKEN CHIEFLY FOR PROTEIN

As has already been said dietitians are accustomed to divide proteins into two classes The first class are those whose distribution of amino acids is similar to that in human proteins, while the second class are those which are *deficient in such amino acids as* lysine, methionine phenylalanine and tryptophane[1] The two classes approximately coincide with animal and vegetable proteins though gelatin is an exception among animal proteins and potato and rice proteins are exceptions among vegetable proteins So that to the dietitian cheese eggs fish meat and milk are the food of greatest value in body building whereas cereal and pulse protein are of secondary value for that purpose Moreover the concentration of proteins is high in foods of animal origin, with the exception of milk, running from 10 to 35 per cent of the raw food whereas cereal and pulse proteins are usually under 10 per cent if we take the values of cooked foods Cooking concentrates the proteins in animal foods but decreases concentration in vegetable foods Consequently animal foods are a concentrated source of body building material whereas vegetable foods have their second rate proteins considerably diluted with water, starch, cellulose etc We have already discussed the proteins of cereals and pulses in the section devoted to foods taken mainly for energy purposes, and it is now necessary to discuss the values of the animal foods

Pre eminent among foods containing proteins of high biological value—' first class proteins '—are eggs milk and milk products and these will be discussed first All estimates of their biological value put egg and milk proteins high[2] They were developed for body building purposes for mammal and birds and though the biological value of their proteins may be best for cows (for example) and ducks and hens, they also have a very high value for human beings

[1] For the importance of methionine in reconstituting animal proteins see PETERS (1945) *Lancet* 1, 266

[2] BOAS FIXSEN (1935) *Nut Abst and Rev* 4, 447

Eggs

An egg is an undeveloped chick. This may sound a truism, but it is the key to the right understanding of the value of eggs as food. For if the chick is developed from the egg without the aid of any external agency save heat and correct gaseous environment as to composition and pressure it follows that the egg must contain within itself all the building material necessary for the making of the chick, along with such a supply of nutriment as the latter requires until it is ready to be hatched. Kingsley's comparison of them with treasure houses is not inapt though unhumorous—and unbiological.[1]

In chemical language, they must contain much protein and inorganic matter (especially calcium, phosphorus and iron) for these are the only materials out of which blood and bone can be built. They are likely also to contain fat for that is the most compact form in which nutriment for the young chick can be stored. And as a matter of fact, it is practically of these constituents that an egg consists. Carbohydrate[2] it need not contain, for the chief use of carbohydrate is, as we have seen, to serve as a source of muscular energy, and in the narrow confines of an eggshell muscular movement is restricted.

Passing on to details it may be said that a hen's egg of average size weighs about 50 grammes (nearly 2 oz.) the weight being distributed as follows

Shell	12 per cent	or 6 grammes
White	58 ,,	29 ,,
Yolk	30 ,,	15 ,,

The *shell* consists almost entirely of carbonate of lime. As the process of hatching goes on it loses some 9 per cent of its weight by absorption and one might think that it was used as a storehouse of lime which is drawn upon for the formation of the bones. Modern research bears out this assumption.

The protein of *white of egg* is called "egg albumin". It is an error however to regard it as a single substance. It consists

[1] Treasure houses wherein lie
Locked by angels' alchemy
Milk and hair and blood and bone

[2] There is a small amount of free carbohydrate material in eggs variously estimated at 40 to 230 milligrammes per egg (NEEDHAM (1931) *Chemical Embryology* 282). In addition there is glucosamine which yields glucose on hydrolysis in ovalbumin and ovomucoid (*ibid.*, 277)

of a mixture of different proteins, some of which are of a compound nature, and contain a carbohydrate group in their molecule [1] The white contains 0 4 to 0 5 milligramme riboflavine per 100 grammes and also avidin a substance which renders biotin a member of the B complex of vitamins unavailable

The *yolk* is the chief storehouse of nutriment for the young chick and consequently has a very different composition from the white It contains much less water and more solid matters, amongst the latter being a large proportion of fat The general composition of the white and yolk is contrasted in the following table (Konig) [2] and graphically illustrated in the accompanying diagrams (Figs 17 and 18)

Composition of Egg

	Water	Protein	Fat	Other Non nitrogenous Matter	Mineral Elements
White	85 7	12 6	0 25	—	0 59
Yolk	50 9	16 2	31 75	0 13	1 09

One can see at a glance that the yolk of the egg is relatively its most nourishing part The complexity of the composition of the yolk is shown by the following detailed analysis of its constituents [4]

Composition of Yolk of Egg

Water	47 to 54 per cent
Proteins	15 , 17 5
Fat	21 , 33 ,
Mineral element	0 5 2 0
Extractives	0 1 , 2 1 ,

The proteins of the yolk are vitellin and livetin, of which the former is a true phosphoprotein and the latter a pseudoglobulin

[1] There are apparently four different proteins in egg white—ovalbumin conalbumin ovomucin and ovomucoid The ovalbumin makes up the greater part of the white Ovomucin and ovomucoid are glycoproteins and are only present in small amounts See Eichholz (1898) *Journ Physiol* 23, 163 Farmers Bull, No 128 U S Dept of Agriculture

[2] See p 160

[3] For further analyses which however do not differ essentially from the above see Lebbin (1901) *Therap Monatshefte* 15, 552 Plimmer (1921) *loc cit* Needham 1931 McCance and Widdowson (1940) give rather lower figures

[4] Compiled from figures given by Needham (1931) *Chemical Embryology* 1, 283–4

Vitellin contains some 1 3 per cent of phosphorus and has relatively high proportions of the important amino acids, cystine tryptophane and tyrosine a fact of some importance in embryonic—and other—nutrition Livetin contains but little phosphorus The proportions of vitellin to livetin are about 3 6 to 1

The "fat in the table is really ethereal extract" and consists of true fats plus lipines The fats are, of course, compounds of fatty acid and glycerine and the fatty acids of egg fat are palmitic, stearic oleic and possibly linoleic—the oleic and the other two being

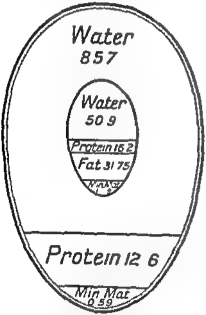

FIG 17—PERCENTAGE COMPOSITION OF THE WHITE AND YOLK OF AN EGG

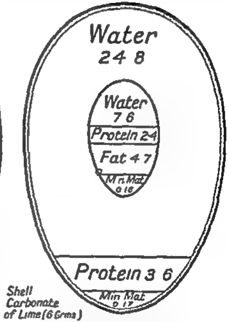

FIG 18—ACTUAL COMPOSITION OF AN AVERAGE EGG WEIGHING 50 GRAMMES

in the proportion of 2 1 1 The lipines are mainly represented by lecithin but there are other members of the group present such as kephalin and sphingomyelin These substances are of interest in nutrition because they too contain phosphoric acid, and can be used as a source of phosphorus for the bones of the developing chick The relation of true fats to the remainder of the fat-like materials is about 2 5 to 1

As much as 200 mgm of cholesterol mainly as free cholesterol are to be found in each egg yolk which probably acts as a carrier of vitamin D

All these unusual substances were for a long time believed to be in chemical combination with the protein, but more recently the general opinion is that the combination is only physical

As regards the inorganic constituents, potassium, calcium and iron,[1] in addition to the phosphorus, are found in considerable amounts in the yolk According to McCance and Widdowson 100 grammes of white and yolk have the following amounts in milligrammes of the "mineral elements"

	White	Yolk.
Calcium	5 2	131 5
Chlorine	170 0	142 0
Copper	0 03	0 02
Iron	0 1	6 13
Magnesium	10 7	14 9
Phosphorus	33 0	495 0
Potassium	148 0	123 0
Sodium	192 0	50 0
Sulphur	183 0	165 0

We have, then, in the yolk of egg a remarkable food, for it contains a protein with a large amount of phosphorus and of high biological value, highly emulsified fats, which owing to their emulsification are very digestible lecithin and its allies also highly phosphorized, and very notable proportions of calcium and iron The phosphorus is needed by the young chick partly to form bones and partly to form nucleoprotein the calcium and the phosphorus are essential for bone formation, the iron[2] for the hæmoglobin of the blood. The fats contain vitamin A (88 I U per gramme yolk) and the sterols vitamin D (up to 5 I U per gramme yolk) Vitamins B_1 (1 I U per gramme) and riboflavine (0 5 to 0 6 milligramme per 100 gramme) are also present in the egg yolk

Consequently the great richness of the yolk in all (or most) of the materials needed by the young growing animal makes it a peculiarly valuable food for infants, especially those who are suffering from rickets

Eggs contain almost no free purine or purine yielding substance, and may therefore form part of the purine free diet which is sometimes recommended in gout

[1] SOCIN (1891) *Zeit f Physiolog Chem*, **15**, 93

[2] The iron is present not as formerly supposed in organic combination but as an inorganic compound. R HILL (1930) *Proc Roy Soc.* **107**, 205 THOMPSETT (1934) *Biochem Journ* **28**, 1536

The *composition of the whole egg* may be summed up as follows [1]

Shell	11 2 per cent
Water	65 5
Nitrogenous matter	13 1
Fatty matters	9 3
Mineral elements	0 9

There is no difference in composition between eggs with dark shells and eggs with white shells and no justification for the popular belief that the former are "richer" than the latter [2]

The composition of the *edible part* (white and yolk together) may be *compared with* that of *meat* thus [3]

	Egg	Moderately Lean Meat
Water	73 7	73 0
Protein	14 8	21 0
Fat	10 5	5 5
Mineral elements	1 0	1 0
Calorie value	168·0	137 0

It is seen at a glance that eggs contain almost the same total of nutritive matter as meat but are relatively richer in fat and poorer in protein

Eggs are thus admirably adapted chemically to supplement a food rich in carbohydrate moderately rich in protein but poor in fat Such a food is found in rice and many cereals, and the addition of eggs to these in the form of puddings makes a complete food

Composition of other Eggs The composition of a goose's or duck's egg is very similar to that of the hen but of course they are larger An average duck's egg weighs about 2½ oz, a goose's egg from 5½ to 6½ oz

Eggs when *kept* gradually lose water by evaporation and become lighter A fresh egg should sink at once in a 10 per cent salt solution (about 2 oz to a pint) but the longer it has been kept

[1] ATWATER *Composition of American Food Materials* Bull No 28 U S Dept of Agriculture (revised edition) The percentage of shell is somewhat lower than that given on p 359 McCANCE and SHIPP (loc cit) found that the whole egg (excluding shell) contained 12 6 per cent protein and 7 9 per cent fat

[2] See C F LANGWORTHY (1901) *Eggs and their Uses as Food* U S Dept of Agriculture Farmers Bull No 128

[3] ATWATER *op cit* (average of sixty analyses)

THE COMPOSITION OF EGGS[1]

	Refuse Per Cent	Water Per Cent	Protein Per Cent	Fat Per Cent	Mineral Elements Per Cent
Duck					
Whole egg as purchased	13 7	60 8	12 1	12 5	0 8
Whole egg edible portion	—	70 5	13 3	14 5	1 0
White	—	87 0	11 1	0 03	0 8
Yolk	—	45 8	16 8	36 2	1 2
Guinea fowl					
Whole egg as purchased	16 9	60 5	11 9	9 9	0 8
Whole egg edible portion	—	72 8	13 5	12 0	0 9
White	—	86 6	11 6	0 03	0 8
Yolk	—	49 7	16 7	31 8	1 2
Hen					
Whole egg as purchased	11 2	65 5	11 9	9 3	0 9
Whole egg edible portion	—	73 7	13 4	10 5	1 0
White	—	86 2	12 3	0 2	0 6
Yolk	—	49 5	15 7	33 3	1 1
Plover					
Whole egg as purchased	9 6	67 3	9 7	10 6	0 9
Whole egg edible portion	—	74 4	10 7	11 7	1 0
Turkey					
Whole egg as purchased	13 8	63 5	12 2	9 7	0 8
Whole egg edible portion	—	73 7	13 4	11 2	0 9
White	—	86 7	11 5	0 03	0 8
Yolk	—	48 3	17 4	32 9	1 2

the nearer the surface it will float There is no reason to suppose that preserved eggs are in any way less nutritious than fresh

When an egg becomes *rotten* alkaline sulphides are produced, apparently from the white, and these give to a rotten egg its very disagreeable smell If an egg is boiled for a long time the same effect is produced in a minor degree, and it is well known that an egg so treated is apt to have a slight odour[2]

[1] U S Dept of Agriculture Farmers' Bull No 234 Other analyses quoted by NEEDHAM (1931) *Chemical Embryology* 1, 240–1, are substantially the same

[2] The green colour of the surface of the yolk of a hard boiled egg is due to the sulphide set free from the white combining with the iron of the yolk This may be prevented by boiling the egg no more than enough to set it and then rapidly cooling it in cold water TINKLER and SOAR (1920) *Biochem Journ* 14, 114

The digestibility of eggs in the stomach depends largely upon the form in which they are taken Some experiments made on a healthy man throw light on this subject [1] Two eggs were given, cooked in different ways, and portions of the stomach contents were withdrawn at intervals the time being noted at which any portion of egg ceased to be recovered The results were as follows

2 eggs	lightly boiled have left the stomach in	1¾ hours
	raw have left the stomach in	2¼ ,,
	poached + [illegible] grammes of butter have left the stomach in	2½ ,,
	hard boiled have left the stomach in	3 ,,
	as an omelette have left the stomach in	3 ,,

The figures speak for themselves Eggs cooked in almost any way are digestible Raw eggs, despite their reputation, may prove to be indigestible Investigations in Mendel's laboratory suggest that they are by no means as useful in nutrition as lightly boiled eggs Their avidin renders the biotin of the diet unavailable

The difference in digestibility between hard- and soft-boiled eggs depends to some extent, also, on the degree to which the former are subdivided If finely chopped up, they could probably be disposed of as easily as the soft-boiled eggs [2]

As would be expected, raw yolk remains considerably longer in the stomach than raw white It is noteworthy that all egg dishes call forth a much smaller secretion of hydrochloric acid than meat and fish [2]

It must also be pointed out that *idiosyncrasy* plays a large part in the digestion of eggs Some persons are unable to swallow even a small particle of egg without becoming violently ill, the symptoms ranging from slight urticaria to vomiting syncope and coma

The *absorption* of eggs in the intestine seems to be very complete It has been found that even when 21 hard boiled eggs are taken daily they are absorbed as completely as meat only [illegible] per cent of the dried substance being lost [3]

[1] PENZOLDT (1893) *Deut Arch f Klin Med* 51 535 See also HAWK REHFUSS *et alii* (1919) *Amer Journ Physiol* 49, 254

[2] HAWK and REHFUSS (1926) found that hard boiled egg remains in the stomach only ten minutes longer than soft-boiled *Amer Journ Med Sci* 171, 359

[3] RUBNER (1879) *Zeit f Biologie* 15, 115 For an account of later experiments which however yielded results almost identical with Rubner's see Farmers Bull No 128 17 U S Dept of Agriculture and AUFRECHT and SIMON (1908) *Deut Med Woch* 34, 2309

Eggs, therefore, leave a very small residue in the intestine This, coupled with the fact that they contain so much calcium may perhaps explain their constipating effect on some persons

Nutritive Value of Eggs Chemical considerations have shown us that the nutritive value of eggs is due almost entirely to protein and fat One egg contains enough of these to yield 70 to 90 Calories Half a tumblerful of good milk or 1½ oz of fat meat would yield about as much

Roughly speaking, 15 to 20 eggs may be taken as the nutritive equivalent of 2 lb of medium fat meat

Their low carbohydrate content prevents eggs from being in any sense a complete food, and it would take 12–15 of them a day to supply even the amount of nitrogen required by a healthy man They cannot be regarded as a *cheap* source of protein though *the convenient form in which their nutritive constituents are pre* sented and the readiness with which they lend themselves to the art of the cook, must always render them a most useful form of food In addition to these considerations the peculiar chemical composi tion of the yolk causes that part of the egg to be a valuable source of calcium, iron and phosphorus, as well as vitamins A, B_1, riboflavine and D of which advantage may well be taken in the dietetic treatment of disease more especially in early life They lack vitamin C

Duck Eggs A word of warning is necessary about duck eggs As long ago as 1926 the Ministry of Health drew attention to the possibility that undercooked duck eggs could cause gastro enteritis The ducks often are carriers of *bact aetrycke* pass them on to the eggs and if the latter are imperfectly cooked, spread ' food poisoning Hens and turkeys suffer from microbes of the salmonella type but so far these birds eggs have not been incriminated as a source of food poisoning German law compels duck eggs to be indelibly stamped as such and advise that they should be boiled for eight minutes [1]

Dried Eggs The war of 1939-45 introduced us to a new product—spray-dried eggs In the first World War, Cook s Farm Eggs gained some prominence and continued to be manufactured during the uneasy peace Their composition was

Protein	43 19 per cent
Fat	41 92
Non nitrogenous matter	1 50
Ash	3 15
Moisture	10 24

[1] *Lancet*, (1945) 1, 314

The spray process of drying milk was applied to whole eggs and a very valuable commodity resulted In fact it "saved the situation" for the cook during the war years The spraying results in a very fine powder which easily "reconstitutes" with water Some change in the physical nature of the proteins results for dried eggs are not so useful as shell eggs in cake making More baking powder seems to be necessary It is claimed however, that reconstituted dried eggs beaten at a temperature of 100° F to 125° F can be used as a basis for sponge cakes and are as useful for that purpose as shell eggs Cane sugar added to the egg before drying prevents the denaturation of the proteins and gives a better beat Other sugars have an opposite effect [1] There can be little doubt of their nutritive value The analysis given by the Medical Research Council is

Protein 45 8 g Fat 42·0 g Carbohydrate 3 2 g Calcium 219 mg Iron 11 mg Vitamin A 3000 I U B_1 1400 I U C, 0 D 240 I U per 100 grammes Calorie value 591 (163 per oz)

It is unfortunate that there are many so called "substitutes" for eggs on the markets Biologically and dietetically there can be no substitute for the egg Among these substitutes are sold the *custard powders*

COMPOSITION OF CUSTARD POWDERS

	Bird's[2] Custard powder	Goodall's Custard powder	Goodall's Egg powder	Borwick's Egg powder	Yeatman's Egg powder
Starch	86 25	84 45	51 03	26 38	52 32
Protein	0 59	0 58	6 01	2 96	[illegible] 00
Soluble colouring matter	0 88	0 90	—	—	—
Baking soda	—	—	15 33	50 70	22 11
Tartaric acid	—	—	13 69	10 33	11 37
Phosphates	—	—	0 24	—	—
Carbonates of calcium and magnesium	—	—	2 70	—	—
Chlorides and sulphates	—	—	—	—	—
Water	11 83	13 69	11 0	9 63	8 20
Mineral elements	0 45	0 38	—	—	—
	100 00	100 00	100 00	100 00	100 00

[1] HAWTHORNE and GROVER (1944) *Chem and Ind* 422

[2] Bird's custard powder has added vitamins A and D

Eggs, therefore, leave a very small residue in the intestine. This, coupled with the fact that they contain so much calcium may perhaps explain their *constipating effect on some persons*

Nutritive Value of Eggs Chemical considerations have shown us that the nutritive value of eggs is due almost entirely to protein and fat *One egg contains enough of these to yield 70 to 90 Calories* Half a tumblerful of good milk or $1\frac{1}{2}$ oz of fat meat would yield about as much

Roughly speaking, 15 to 20 eggs may be taken as the nutritive equivalent of 2 lb of medium fat meat

Their low carbohydrate content prevents eggs from being in any sense *a complete food, and it would take 12–15 of them a day to* supply even the amount of nitrogen required by a healthy man They cannot be regarded as a *cheap* source of protein though the convenient form in which their nutritive constituents are presented and the readiness with which they lend themselves to the art of the cook must always render them a most useful form of food In addition to these considerations the peculiar chemical composition of the yolk causes that part of the egg to be a valuable source of calcium, iron, and phosphorus as well as vitamins A, B_1, riboflavine and D of which advantage may well be taken in the dietetic treatment of disease, more especially in early life. They lack vitamin C

Duck Eggs A word of warning is necessary about duck eggs As long ago as 1926 the Ministry of Health drew attention to the possibility that undercooked duck eggs could cause gastro enteritis The ducks often are carriers of *bact aetrycke*, pass them on to the eggs and if the latter are imperfectly cooked spread 'food poisoning' Hens and turkeys suffer from microbes of the salmonella type, but so far these birds eggs have not been incriminated as a source of food poisoning German law compels duck eggs to be indelibly stamped as such and advise that they should be boiled for eight minutes [1]

Dried Eggs *The war of 1939–45 introduced us to a new* product—spray-dried eggs. In the first World War, Cook s Farm Eggs gained some prominence and continued to be manufactured during the uneasy peace Their composition was

Protein	43 19 per cent
Fat	41 92
Non nitrogenous matter	1 50
Ash	3 15
Moisture	10 24

[1] *Lancet* (1945) 1, 314

CHAPTER XIV

FOODS TAKEN CHIEFLY FOR PROTEIN (*cont*)

MILK

There is probably only one subject upon which all dietitians agree, viz the value of milk—generally speaking cow's milk—in human nutrition Milk is a food developed in nature for the feeding of the immature mammal The only doubts which can arise about its use by man are (i) is it wise to divert the food intended for the young of other mammals to man and (ii) should adults take a food intended for the immature? The answer to these two questions from the dawn of history to the modern experimental era is undoubtedly yes

In the present chapter cow's milk alone will be dealt with We shall reserve till later the study of human milk and the milk of some other animals

Chemical Composition As regards its chemical composition, milk occupies an almost unique position among animal foods for it contains in itself representatives of all three nutritive constituents proteins carbohydrates, and fat The avocado pear nuts and the soya bean are practically the only other foods which have significant amounts of all three nutrients to judge from McCance and Widdowson's analyses The Medical Research Council includes the shell fish

The ***proteins of milk*** constitute about 3 to 3½ per cent of its total weight [1] The principal protein is the substance called *caseinogen* [2] which is not very soluble in pure water but is kept in solution in milk by the various inorganic salts present The solution is not clear but opalescent It is least soluble at a p_H 4 6

The other main protein of milk is an albumin (*lactalbumin*) which is present in very much smaller quantity than caseinogen making *up only about one fifth of the total protein of cow's milk* In human milk it is *relatively* much more abundant The biological value of the mixed proteins is the highest known and because of

[1] Average of all data in DAVIES (1939) *The Chemistry of Milk* Chapman & Hall are protein 3 42 fat 3 67 lactose 4 78 mineral elements 0 73

[2] Casein in American and Continental terminology

The majority of them consist chiefly of starch, to which a yellow colour is imparted by mixture with some vegetable dye—e g turmeric

It is obvious that they have nothing in common with eggs except a yellow colour and that their nutritive value can be in no way equal to that of a genuine custard They are extremely popular in all parts of the country served with stewed fruits, with fruit pies and with suet puddings but are useful in dietetics only as a vehicle for milk

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their large content of methionine are particularly useful for tissue building and regeneration [1]

The ***carbohydrate*** constituent of milk is *milk sugar*, or *lactose*, which is present to the extent of from 4 to 5 per cent It differs very much from cane sugar and in nothing more than in its comparative freedom from sweetness In a substance which serves as a food rather than as a condiment, this property is a valuable one Were it not so, milk would pall upon the taste much more readily than it does Another peculiarity of lactose is that it is hardly capable of being fermented by yeasts As a consequence, it is better borne than other kinds of sugar in cases of advanced dilatation of the stomach accompanied by fermentation On the other hand it is readily converted into lactic acid by the lactic acid bacteria, a process which occurs in the souring of milk, and sometimes also in the intestine

The ***fat of milk*** stands intermediate in amount between the protein and sugar in cow s milk, constituting about $3\frac{1}{2}$ to 4 per cent of the total weight In the milk of other mammals the relative proportions vary remarkably, so that generalizations are impossible as the following table will show [2]

COMPOSITION OF THE MILKS OF VARIOUS MAMMALS [3]

	Protein		Fat	Lactose	Mineral elements
	Caseinogen	Lactalbumin			
Ass	0 7	1 6	1 6	6 0	0 5
Buffalo	5 8	0 3	7 5	4 1	0 9
Cat	3 1	6 0	3 3	4 9	0 6
Cow	3 0	0 5	3 7	4 9	0 7
Dog	6 1	5 1	9 6	3 1	0 7
Echidna aculeata	8 4	2 9	19 6	2 8	—
Elephant	3 1		19 6	8 8	0 6
Ewe	5 0	1 5	6 9	4 9	0 9
Goat	3 2	1 1	4 8	4 4	0 8
Human	1 0	1 3	3 8	6 2	0 3
Llama	3 0	0 9	3 2	5 6	0 8
Mare	1 2	0 1	1 2	5 7	0 3
Porpoise	11 2		48 5	1 3	0 6
Reindeer	[illegible] 38	1 51	17 05	2 82	—
Sheep	[illegible]	1 45	8 63	4 28	0 97
Sow	3 3	1 5	7·0	3 1	1 1
Whale	—	—	43 7	—	—

[1] HIMSWORTH and GLYNN (1945) *Proc Roy Soc Med* 38 101, CROFT and PETERS (1945) *Lancet* 1, 260

[2] See also DAVIES (1939) *op cit* 7

[3] Figures mainly from DAVIES (1939) *op cit*

Fat exists in milk in the form of an emulsion of extraordinary perfection The average diameter of a globule of milk fat is about 2 3 to 4 0μ, though there may be some with a diameter greater than 12 It will be evident that fat so finely divided as this must be particularly easy of digestion

When milk is allowed to stand, the fat globules run together, and float to the surface as cream If this is removed, *skim milk* is left but when so prepared it still contains some 0 5 per cent of fat perhaps as much as 1 per cent If the cream is removed by means of a centrifugal separator, its abstraction is much more complete for separated milk usually contains less than ¼ per cent of fat Milk so prepared should be described as *separated milk*

Some fuller chemical details about milk fat have already been given under butter (p 285)

"*Mineral Elements* are fairly abundant in milk forming about 0 7 per cent Seeing that milk is the sole food of young animals, one is not surprised to learn that its different mineral ingredients are present in the same proportions as in the body of the particular animal which the milk is designed to feed [1] Now the chief tissues which a young animal has to build up are muscle and bone For the former potassium phosphate and for the latter calcium phosphate are required and milk contains an abundance of both of these substances To the rule that the mineral ingredients of milk correspond proportionately to those in the body of a young animal there is one apparent exception Iron is an essential element in the body and especially in the blood but iron is very scantily represented in milk [2] Five pints of milk would be required to supply the amount of iron necessary for a full grown man every day To the young animal this scarcity of iron in milk is a matter of little moment It enters the world with a full supply of iron already stored in its body which it has obtained from the blood of its mother Artificially fed babies require extra iron for cow s milk has less iron than human milk [3] In the adult on the other hand the lack of iron entails a deficiency in the supply required to keep the blood in proper condition and for this reason persons who are kept for a long time on a purely milk diet may become anæmic

There remains one other substance which for the sake of convenience may be considered under the mineral ingredients of milk *citric acid* It is rather astonishing to find this substance in milk

[1] Man is an exception

[2] REIS and CHAKMAKJIAN (1932) *Journ Biol Chem* 98, 237 give the percentage of iron in cow s milk when milked into glass containers as 0 00014–0 00018 and when into normal containers as 0 00028

[3] MACKAY H *Med Res Council Spec Rep* No 157.

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Composition of the Milks of Various Mammals [3]

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Elephant	3 1		19 6	8 8	0 6
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Goat	3 2	1 1	4 8	4 4	0 8
Human	1 0	1 3	3 8	6 2	0 3
Llama	3 0	0 9	3 2	5 6	0 8
Mare	1 2	0 1	1 2	5 7	0 3
Porpoise	11 2		48 [illegible]	1 3	0 6
Reindeer	8 38	1 51	17 09	2 82	—
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Sow	3 3	1 5	7 0	3 1	1 1
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To some extent these variations in composition are unavoidable, depending as they do on the breed and age of cow from which the milk is obtained on the way in which the cows are fed, and on the period which has elapsed since calving

In the mixed milk obtained from a large number of cows these variations must to a considerable extent neutralize one another Hence it is that the total milk from one dairy varies less in composition than that from any one cow in it and the popular prejudice in favour of feeding an infant on milk from one cow " thus rests on a false basis The solids not fat ' are closely grouped round an average of 8 74 but even so they may vary from 6 24 to 10·24 per cent The fat of the milk of a Friesian herd may be 3 55 per cent and from a Guernsey 5 10 per cent

What composition should be expected? On this point, unfortunately, some difference of opinion exists Analysis has clearly shown that an average sample of good milk contains about 3 8 per cent of fat There is no legal definition of milk, but it is assumed in this country, that if milk has less than 3 per cent fat, and 8 5 per cent ' total solids not fat,' it is adulterated A quality standard based on total solids and on the number of microbes per millilitre is advocated by Davis[1] of the National Institute for Research in Dairying which certainly would be better than the present haphazard scheme

From what has been said of the chemical composition of milk, it might naturally be regarded as a fluid form of food and indeed it is often one of the chief elements in a so called fluid ' diet Strictly speaking, however, milk is not a fluid food It is only a fluid outside the body So soon as milk enters the stomach it undergoes a change by which it very quickly becomes solid It is then said to be coagulated or clotted This *coagulation* is due to a change brought about in the caseinogen by the ferment called rennin ' The exact nature of the change which the caseinogen undergoes is still obscure, but it seems to be split up by the rennin into two proteins, casein and whey albumose The union of casein and calcium produces the clot[2]

The coagulation of milk is what occurs in the making of *junket*

[1] DAVIS (1944) *Food Manufacture* 19 423

[2] English physiologists as stated above apply the name ' caseinogen to the chief protein of milk and restrict the term ' casein to caseinogen which has been altered by coagulation This nomenclature has the advantage of emphasizing the difference between the products of curdling and clotting above described Adopting it one would say that when milk is curdled caseinogen is thrown down in a flocculent form when milk clots the caseinogen is converted

G*

about 13–0 23 per cent is present and it has been ... a good cow yields as much citric acid in the day as contained in two or three lemons [1]

... in milk, citric acid is chiefly combined with calcium and ... The solid particles sometimes met with in autoclaved ... consist chiefly of it

... addition, milk is [redacted] good source of vitamin A and riboflavine ... pint of milk may yield from 776 to 1520 I U of vitamin A [2] ... min B_1 is present to about 23 I U per 100 c c, though American ... es are lower, riboflavine to 0 2 milligrammes and nicotinic acid to 0 057 milligrammes [3] The other members of the B complex are present Vitamin C [redacted] at about the low level of 2 milligrammes per 100 c c Figures for vitamin D are 7 to 10 I U for English milk between November and March rising to 55 I U in July and possibly higher in August [4]

Last, but not least, amongst the constituents of milk [redacted] *water* It forms by far the largest proportion of the milk (87 to 88 per cent), and holds the other ingredients in suspension or solution The hydrogen ion concentration of fresh cow s milk is P_H 6 5

One may now sum up what has been stated about the chemical composition of milk in the following table

COMPOSITION OF COW S MILK

Water	87 to [redacted] per cent	Fat	3½ to 4½ per cent
Protein	3 3½ ,	Mineral elements [5]	0 7
Sugar	4 [redacted]		

The average figures of thousands of analyses are Water 87 1 total solids 12 69 caseinogen 2 86 albumin plus globulin (coagulable proteins) 0 56 fat 3 67 lactose 4 78, mineral elements 0 73 per cent

These figures merely represent the average composition of a sample of good milk They are not to be understood to apply to every specimen of milk encountered for milk varies greatly in composition

[1] HENKEL (1888) *Munch Med Woch* 35, 328

[2] The MEDICAL RESEARCH COUNCIL figures are about half these and figures from a private communication by COWARD and BRUCE nearly double

[3] Much higher figures are quoted as the result of biological assays It must not be forgotten that milk may promote the growth of nicotinic acid producing microbes in the large intestine

[4] KON (1943) *J Dairy Res* 13, 216

[5] Calcium forms 0 120 per cent potassium 0 160 per cent (an unexpectedly high figure) and phosphorus 0 095 per cent

To some extent these variations in composition are unavoidable, depending as they do on the breed and age of cow from which the milk is obtained on the way in which the cows are fed, and on the period which has elapsed since calving

In the mixed milk obtained from a large number of cows these variations must to a considerable extent neutralize one another Hence it is that the total milk from one dairy varies less in composition than that from any one cow in it and the popular prejudice in favour of feeding an infant on milk "from one cow" thus rests on a false basis The "solids not fat" are closely grouped round an average of 8 74, but even so they may vary from 8 21 to 10·24 per cent The fat of the milk of a Friesian herd may be 3 55 per cent and from a Guernsey 5 10 per cent

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n that process, rennet (an extract of the lining of the fourth or true stomach of the calf or lamb) is added to the milk raised to body temperature, which is then set aside in a warm place until it is solid At first the milk forms a jelly, but by and by the curd shrinks and a yellowish fluid is squeezed out of it, which is the "whey" The rennet which is used in this operation is derived from the lining membrane of the stomach of the calf, but exactly the same ferment is present in the human stomach, and it is important to remember that all raw milk is converted in the stomach into junket very shortly after it has been swallowed We shall return in greater detail to this subject when we come to the digestion of milk

At present it may be pointed out that the curd of milk consists primarily of the calcium caseinate In process of setting, however, the casein entangles the fat of the milk in its meshes, so that curd consists of the casein along with the fat

It usually also contains some of the sugar of the milk, for the whey is never entirely squeezed out

The **"curdling" of milk** must be distinguished clearly from the process of "clotting" just described When milk "curdles" its caseinogen is simply thrown down in the form of a precipitate without undergoing further change When milk "clots" the caseinogen undergoes partial digestion and one of the digestion products unites with calcium to form a clot

Curdling is due to the production of lactic acid in the milk which turns the caseinogen out of its partnership with calcium salts and the caseinogen, being in itself not soluble falls down as a flocculent precipitate when the P_H of the fluid reaches the isoelectric point

The production of the lactic acid is due to a splitting up of milk-sugar by the agency of the lactic acid bacteria The true lactic acid bacteria change 90–98 per cent of the milk's lactose to lactic acid, and there is also a production of succinic, acetic, and propionic acids and of carbon dioxide Coliform organisms also manufacture lactic acid among a wider range of products

Effects of Heating upon the Composition of Milk When milk is warmed in an open pan a tough "skin" forms on the top This skin is due to a Ramsden phenomenon The caseinogen and lactalbumin are concentrated at the air liquid interface and

into casein Americans and others call the chief protein of milk casein and the solid result of rennin action paracasein

Investigation suggests that the calcium is in close relation with the caseinogen in milk forming calcium caseinogenate Curdling with acid removes the calcium and forms acid caseinogen The clot of milk is calcium caseinate

irreversibly precipitated Fat and deposits of tricalcium phosphate are also entangled in the skin

If the skin is removed another straightway appears and by continuing the process the milk undoubtedly loses some of its nutritive value The loss is never great however for 100 c c of milk if boiled for a quarter of an hour lose at most only 0 273 gramme of protein After prolonged boiling, and to a less degree after pasteurization the soluble calcium of the milk is somewhat diminished and to this extent the nutritive value of the milk may be slightly impaired [1]

Other changes observed in milk heated for a long time are that it becomes of a somewhat brownish colour, and altered taste The change in colour seems to be due in part to a caramelization of the sugar in the milk but in part also to more obscure alterations [2] The change in taste sets in quite suddenly when a temperature of 70° C is reached It can be obviated to a large extent by allowing the milk to stand for some time, after being boiled and then straining it

The caseinogen also seems to undergo some alteration on boiling, for boiled milk coagulates more slowly than raw milk. To this point we shall return later

That milk is a valuable food, if not *the* most valuable food, is agreed by all dietitians, and national governments have accepted the verdicts of scientists Colossal efforts have been made by them to increase the production and consumption of milk By subsidizing milk by decreasing its price to pregnant and nursing mothers to infants under five and to school children the consumption of liquid milk in this country has been increased during the years of the second World War by 25 per cent [3] i e from 767 million gallons per year to 1048 million gallons Much of this has been however diverted from manufacture, so that the total increased production is much less spectacular The increased consumption must be continued and further developed if Great Britain is to reach the aim of dietitians viz 1 pint per head per day, or 2 054 million gallons per year

That milk arrives in the towns of this country in a satisfactory state can hardly be claimed by even the most fanatical upholder of the consumption of raw milk Milk as drawn from a healthy and perfectly clean cow is a practically sterile fluid Such ideal conditions however, are difficult, and almost impossible to attain at present

[1] H E MAGEE and DOUGLAS HARVEY Studies of the Effect of Heat on Milk (1926) *Biochem Journ* 20, 873

[2] WRIGHT (1924) *Biochem Journ* 18, 245

[3] *Food Manufacture* (1945) 20, 78

and the production and consumption of milk presents us with a dilemma either we must insist that all milk sold should be absolutely clean milk or it must be treated before consumption to make it safe

The sources of danger are (i) disease in the cow, and (ii) contamination with pathogenic microbes in the course of production transit to the central depots and delivery to the customer The cow may be suffering from tuberculosis or from undulant fever [1] and pass the microbes causing these diseases into the milk secreted The milker may be a carrier of diptheria dysentery, paratyphoid, scarlet fever or typhoid germs and so infect the milk The containers—buckets, churns, etc, may be washed with water infected by pathogenic germs or such germs may be transmitted by flies Then there is the danger of contamination by dust The germs of undulant fever may live for many months in dung and it is unfortunately the fact that much of our milk is contaminated with dung The bulking of milk at distributing centres, or earlier hands on the milk infection of one farm to the whole of the milk bulked, e g in Bournemouth in 1936 a turnover of 1600 gallons of milk per day, collected from 37 suppliers was contaminated by one supply of 15–20 gallons per day infected at the farm There were 718 cases of typhoid with 51 deaths [2] Unfortunately there is evidence of transmission of the diseases mentioned in plenty Transmission of diptheria by the wife of a farmer when straining the milk was demonstrated in 1943 [3] Even milk from tuberculin tested herds is at times contaminated with bovine tuberculosis [4] Press in' discs for closing the mouths of milk bottles have been held responsible for paratyphoid and typhoid in America [5] An outbreak of typhoid in Melbourne was traced to the milk of one farm, where there was a typhoid carrier and with the removal of that carrier the outbreak died out [6] Five per cent of all milk samples in this country bacteriologically tested, contain tubercle bacilli [7] The deaths from bovine tuberculosis, almost *certainly transmitted by milk, are estimated at 2000 per year in this country* [8] Such a death rate indicates great suffering in intestines joints and glands among children who survive These are but a small sample culled mainly from one medical journal

[1] WILSON (1944) *Proc Nut Soc* 2, 158
[2] ENOCK. (1943) *This Milk Business* 75–7
[3] GOLDIE and MADDOCK (1943) *Lancet* 1, 285
[4] SUTHERLAND (1943) *Lancet* 1 316 [6] *Lancet* (1943) 1, 687
[5] MERRILEES (1943) *Lancet* 1, 803 [7] *Lancet* (1945) 1, 187
[8] GARROD (1943) *Lancet* 1, 276 WILSON (1944) *Proc Nut Soc.* 2, 158

during six months It is no wonder that the many medical men look upon milk as a highly dangerous food

There is a great distinction between safe milk—which we cannot afford to wait for—and clean milk which we may hope to get in time [1] The question is how are we to make milk safe until we can be sure of clean milk? The answer is emphatically *pasteurization* This answer will be hotly contested, but frankly we cannot understand the case against it Pasteurization consists in raising the temperature of the milk to a definite degree and maintaining it at that temperature till the pathogenic microbes are destroyed and then at once cooling it and delivering it into sterilized containers The length of time the milk is exposed to the raised temperature depends on that temperature At 145° F the time is 30 minutes (the holder process) but at a higher temperature, the time necessary for the destruction of pathogenic microbes is much shorter At 162° F it may be as low as 15 to 16 seconds (High temperature short time process or the flash process) Both methods are in use in this country and the United States The holder process is being superseded by the flash process which is now permissive in this country Both methods need technical skill in the operator and this is particularly true of the flash process and owing to shortage of skilled labour during the war of 1939–45, some milk has been imperfectly pasteurized [2] It should not be impossible however, to make the apparatus fool proof

The advantage of pasteurizing milk lies not only in the destruction of pathogenic microbes The keeping quality is much enhanced If ordinary milk is pasteurized in the laboratory by the holder process and held at 34° F it will keep without significant change for one month [3] It is safe to say that no milk could be used in our great cities without pasteurization so that the position of affairs is this a large majority of the nation would have to do without this admirable food if a ban were placed upon pasteurization

There is no evidence that pasteurization appreciably alters the food value of milk Laboratory experiments have shown that the only nutritive losses suffered by the known constituents of milk are a destruction of some 20 per cent of vitamin C and of about 10 per cent of vitamin B_1 [4] No one advocates milk as a source of these vitamins, for its contribution in a mixed diet under the best conditions is small There is no loss of vitamin A riboflavine or vitamin D Experiments on calves by the Hannah Research

[1] MONCRIEFF (1943) *op cit*
[2] SUTHERLAND (1943) *Lancet* **1**, **316**
[3] MATTICK (1944) *Proc Nut Soc* **2**, **141**
[4] KON (1944) *Proc Nut Soc* **2** **153**

Institute leave no doubt of its value as a food The growth re
of these calves was as great as—actually slightly greater t
the growth of the controls on the milk from the same sourc
unpasteurized, and whereas none of those on pasteurized
contracted tuberculosis, several of those on raw milk did
difference between the two milks as regards *nutritive val*
be shown on calves it is unlikely that there is any differen
human beings For experiments on the value of pasteurized
in the feeding of children, see p 386

For ordinary purposes there is little doubt that simply b
the milk for a few minutes is the simplest and most satisfa
method of ridding the milk of pathogenic microbes If carrie
in a double saucepan, very little change in taste of the milk re
especially if it is rapidly cooled after removal from the fire
subsequently strained as already described

There is every reason to advocate the habitual application o
or other of these methods to milk before it is consumed as f
and one looks forward to the day when the drinking of raw milk w
considered as barbarous a custom as the eating of raw meat
present

Preservation of Milk The commonest methods of pres
ing milk are by evaporation or desiccation

Evaporated milk (usually spoken of in this country as
sweetened condensed milk) is made on a large scale in Amei
By evaporation *in vacuo* the water content of the milk is redu
by 60 to 65 per cent the fat is homogenized to break up the glob
and the product is finally sterilized Such a milk is germ free
the evaporation being conducted in the absence of oxygen tl
is no appreciable loss of vitamins A and D, but there is a loss
50 per cent of the vitamin B_1, 10 per cent of riboflavine and
per cent of vitamin C[1]

By the method of ***desiccation,*** milk is passed in a thin la
between two heated rollers, or sprayed into a current of hot
in such a way that most of the water is immediately evaporated a
a fine powder results which contains all the original solids of t
milk in a perfectly soluble form There are now many brands
dried milk on the market, of which the table on the opposite p
may be regarded as giving the approximate composition

The nutritive value of dried milk is fully equal to that
ordinary milk and it may be regarded as practically sterile and
is more digestible

[1] Kon (1944) *Proc Nut Soc* 2, 149

Composition of Dried Milk

	Whole	Skimmed
Moisture	4·0 per cent	5·0 per cent
Proteins	2[illegible]·6	3[illegible]·8 ,,
Fat	26·7 ,,	0·7 ,,
Milk sugar	35·6	47·9 ,,
Calcium	0·89 ,,	1·225 ,,
Iron	0·8	1·0 mg per 100 gms
Vitamin A	1070	30 I U
Vitamin B_1	100	330 ,, ,,
Vitamin C	0	0 ,, ,, ,,

Digestibility of Milk

It might be supposed that milk being a fluid would only remain a short time in the stomach, and rapidly pass on into the intestine We have seen however that milk is only a fluid outside the body

Clotting of Milk in the Stomach When it enters the stomach it sets into a solid clot, owing to the action upon it of rennin Now, the gastric juice is an acid fluid and it is at first sight surprising that *curdling* does not take place rather than clotting That this does not happen is no doubt to be attributed to the fact that the proteins of the milk unite with the acid first secreted by the stomach and give the rennin time to act before the mixture has attained an acid reaction

Whether this is the correct explanation or not there can be no doubt of the fact that shortly after milk has been swallowed it is converted into a solid mass

What the use of rennin is in the stomach is very difficult to see Certainly clotting is not a necessary preliminary to the digestion of milk, for the latter process can be carried on artificially outside the body to its most advanced stages with the milk remaining fluid all the time There is also ample provision for the digestion of milk in the intestine and if it is so prepared that clotting in the stomach cannot take place its ultimate digestion is in no way interfered with nor is it found that patients from whom the stomach has been entirely removed for disease have any difficulty in digesting milk Rennin, in fact, would almost appear to be a superfluous ingredient in the gastric juice, and its presence there is rendered all the more inexplicable by the fact that it occurs also in such situations as the gizzards of fowls, where milk is never found at all

After the clot of casein has formed in the stomach it shrinks into

a tough and leathery mass, which offers great resistance to the digestive efforts of the organ Were the milk merely curdled the case would be quite different for the particles of precipitated caseinogen are dissolved with comparative ease This is one of the reasons why butter milk and koumiss are often found to be more 'digestible' than ordinary milk

The investigations of VAN SLYKE and HART have thrown a light on the digestion of casein Calcium caseinate, which is the clot formed by rennin, forms a flocculent curd, which is not digested by pepsin unless acid is present but passes almost straight into the intestine This happens in young infants whose stomachs secrete little or no hydrochloric acid If acid is present, casein is set free and forms a much denser clot, and is digested by pepsin If hydrochloric acid is in excess casein hydrochloride is formed, which sets into a still tougher curd and takes still longer to digest

If, then we wish to lighten the labours of the stomach in the digestion of milk we must endeavour so to arrange matters that the milk shall not form a tough and dense clot *after* it has been swallowed

Now, the density of the clot which milk forms in the stomach depends, on the one hand, upon the amount of caseinogen and calcium salts which it contains and on the other hand upon the degree of acidity of the gastric juice The richer in caseinogen and soluble salts of calcium the milk is, and the more acid the gastric juice, *the tougher is the clot* On the other hand by reducing the proportion of these different factors the clotting of the milk can either be prevented altogether or made to take place in such a way that the clot is not of great toughness and density

Obviously mere ***dilution of the milk with water*** lessens the proportion of lime salts and caseinogen, and will increase its digestibility ***Dilution with lime-water*** is probably not more efficacious than dilution with ordinary water[1] unless it be in virtue of its slight alkalinity *It has been found however, that the addition of even large quantities of such an alkali as bicarbonate of soda to milk does not prevent clotting in the stomach*

Barley-water is sometimes recommended as a diluent instead of ordinary water Whilst it has no greater power of preventing clotting than ordinary water, it seems to some extent, by its colloidal properties, to prevent the clot from shrinking into a tough mass This is due to starch which it contains

[1] See F W WHITE (1901) 'Observations on Milk Coagulation and Digestion' (Abstract in *Boston Med and Surg Journ* 145 13)

Wright[1] showed that the coagulation of milk can be prevented by the addition of one-fiftieth of its volume of a 25 per cent solution of citrate of soda which acts by converting some of the soluble lime salts into insoluble calcium citrate Such *citrated milk* is employed with success in the feeding of infants The presence of the citrate can hardly be detected by the palate, and milk contains such a large excess of calcium salts that the removal of part of them is no disadvantage

Aeration of the milk (such as can be effected by the use of the Sparklets' process) is another important means of combating density of clotting Milk so prepared clots rapidly but the clot is very friable It is the combination of aeration and dilution that renders milk-and-soda so much more digestible than plain milk

The presence of much acid as has been mentioned favours the retraction of the clot into a leathery form Now, the degree of acidity of the gastric juice varies in different individuals within fairly wide limits and that may explain why some people find milk so much more easy to digest than others For this reason, too milk may sometimes disagree in those cases of dyspepsia which are caused by over acidity of the gastric juice

Another method of preventing the formation of a dense clot is by mixing the milk with some substance which will get in between the particles of casein as it were and keep them apart, so that they do not run into a solid tough mass but form a more or less spongy clot Mucilaginous fluids, such as barley water, act, as we have seen in this fashion Thickening the milk with a little cornflour or gruel acts similarly, so does mixture with other foods Milk is thus more easily digested if eaten along with some solid food—e g a biscuit—than when drunk straight off by itself

Boiled milk is found to clot more slowly both *in vitro* and *in vivo* and to give a less dense clot than raw milk[2]

The exact *time that milk remains in the stomach* under ordinary circumstances has been determined by causing a healthy man to drink a definite quantity of milk and then washing out the stomach at short intervals or by taking advantage of people who can regurgitate at will

In a series of experiments on the gastric response to foods Rehfuss Hawk and their colleagues[3] made the following observations on such a man

[1] On the Possible Advantages of Employing Decalcified Milk in the Feeding of Infants and Invalids *Lancet* (1893) 2 194 GONCE and TEMPLETON (1930) *Amer Journ Dis Child* 39 265

[2] BRENNEMANN (1913) *Journ Amer Med Assoc* 1 575

[3] *Amer Journ Physiol* (1919) 48 411

a tough and leathery mass, which offers great resistance to the digestive efforts of the organ Were the milk merely curdled, the case would be quite different, for the particles of precipitated caseinogen are dissolved with comparative ease This is one of the reasons why butter milk and koumiss are often found to be more digestible' than ordinary milk

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escape digestion even if it be so prepared that it does not remain in the stomach but rapidly passes through into the intestine

The question next arises Is the digested milk completely absorbed or does it leave behind any considerable amount of waste residue? This question may be approached by investigating the degree to which the different constituents of milk are absorbed when isolated and given alone Proceeding in this way it has been found that the casein of milk is the best absorbed of proteins It is absorbed as well as or even rather better than, the protein of meat whilst the fat of milk enters the blood quite as readily as the fat of beef And one may note in passing the interesting fact that the fat of aerated milk is absorbed rather better than that of milk which has not been so treated We are not aware of any experiments in which milk sugar was given by itself, but it is usual to assume that it is completely absorbed

Considering these facts, one would naturally expect to find that when milk was given as a whole it would be well absorbed If the different components of it are so completely received into the blood surely the whole of them given together will enter the blood with equal ease and completeness? But yet it is not so Milk *when given by itself as the exclusive diet of an adult* is not very well absorbed—worse indeed than any other animal food Even under favourable conditions only about 90 per cent of the energy theoretically obtainable from milk is so obtained The rest is lost as unabsorbed waste Thus, if 2 litres of milk are taken daily the loss of dry substance amounts to 5 7 to 7 8 per cent On 3 litres the waste rises to 10 2 to 11 16 per cent (Rubner) Prausnitz found a loss of 9 per cent when 3 litres were consumed daily One gramme of dried milk ought to yield 5 733 Calories Owing to defective absorption, it only yields in the body 5 067 Calories The loss affects the proteins and fat about equally and in a notable degree the inorganic constituents and carbohydrates as well

These results apply only to the case of adults and when milk is the sole food When the milk forms part of a mixed diet it is much better absorbed Thus in an average of ten experiments given by Wait in which milk was the exclusive food only 92 1 per cent of the protein and 86 3 per cent of the carbohydrate were digested but in five experiments in which the diet consisted of bread and milk the proportion digested rose to 97 1 per cent of the protein and 98 7 per cent of the carbohydrates The large amount of water which milk contains seems to interfere with absorption when it forms the sole diet [1]

[1] *Nutrition Investigations at the University of Tennessee* U S Dept of Agriculture Bull No 53 p 43

(1) Milk (500 c c) drunk rapidly, leaves the stomach rapidly and produces smaller curds than milk drunk slowly or *sipped* *Sipping* produces large tough curds which remain a long time in the stomach

(2) Raw milk produces rubber like curd milk, boiled 5 minutes, smaller and more digestible curds which leave the stomach earlier

(3) Skimmed milk produces tough, hard curds, *full milk softer curds and cream very soft curds* The last, however, leave the stomach but slowly

(4) The addition of bicarbonate of soda produces smaller curds, not so small as those of boiled milk, which stayed longer in the stomach than those from untreated milk

(5) Pasteurized milk is intermediate between raw and boiled milk

(6) There is no observable difference between warm and cold milk as regards the size of curds formed and the rate of passage through the stomach

One or two other points bearing on the digestibility of milk still remain to be mentioned They specially affect its use in diseases of the stomach

In the first place, it must be pointed out that, thanks to its protein phosphates and citrates milk *can act as a powerful buffering agent*[1] In some diseases of the stomach, such as ulceration, in which it is desirable to buffer the acidity of the gastric juice, this property of milk makes it a valuable article of diet It has also been pointed out by Pavlov that, in proportion to the amount of nitrogen it contains, milk requires for its digestion a weaker gastric juice than any other food Hence, the secretory work required of the *stomach for its digestion* is small, and this is another point in its favour in many diseased conditions of the stomach The fat which milk contains also exerts a restraining influence on the amount of gastric juice secreted Lastly, milk, like soup, and a few other articles of diet, seems to produce a secretion of gastric juice independently of reflex nervous influences It is therefore as sure to be digested if poured into the stomach through a tube as if it had been swallowed in the ordinary way This is by no means true of most foods

Absorption of Milk

Leaving the stomach the milk reaches the intestine, where its *digestion is completed* by the pancreatic juice This juice *acts very powerfully* on milk—more so than the gastric juice By reason of this provision there is no need to fear that milk will

[1] Ten c c of cow s milk can neutralize 4 c c of decinormal sulphuric acid

sound foods A perfect food must supply first class protein, highly assimilable fats and carbohydrates all the 'mineral' elements in their right proportions, and all the vitamins All this it should do at a moderate cost and in reasonable bulk

Milk supplies first class proteins and the minimal day's ration is found in 1 quart—not an unreasonable quantity and costing 9d Even at this high price per quart milk compares very favourably with meat

Its fats are highly assimilable and decrease the need for vitamin B_1 Its carbohydrate while not very assimilable is none the less very useful in metabolism

Milk contains excellent supplies of calcium and phosphorus but is deficient in iron Of the vitamins it possesses A riboflavine and vitamin K in considerable amount it is not devoid of B_1 though its content of C and D are not worth considering[1] No other food than eggs can be said to be so valuable as milk

As sole food milk is too bulky contains too little iron and is not completely assimilable

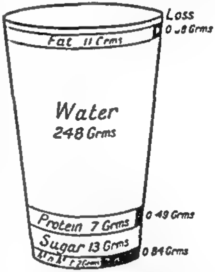

FIG 19—ACTUAL COMPOSITION OF A TUMBLERFUL OF ORDINARY MILK AND THE PERCENTAGE OF LOSS FROM NON ABSORPTION

We conclude, then that milk is not a perfect food, but it is admirably fitted to supplement the deficiencies of other articles of diet It is one of the cheaper sources of animal protein Ninepenny worth of whole milk yields as much protein as tenpenny worth of beef steak But milk has the advantage over beef of containing a considerable amount of carbohydrate in addition to its protein and fat and a quart of good milk is equal in Calorie value to a pound of lean beef steak Skim milk is an even better source from which to supplement any lack of protein in the diet for it supplies that constituent in a cheaper form than any other animal food except salt fish Its

[1] The cholesterol content of cow's milk—10 to 17 milligrammes per 100 c c —gives it its antirachitic power on irradiation which may be as much as 67 I U per pint BICKNELL and PRESCOTT (1942) *The Vitamins in Medicine* 463

It is an interesting and remarkable fact that milk is much better absorbed by young children than by grown up persons[1] Thus, even up to the age of 12 the loss of nitrogen, when milk is given alone, is only 4 4 per cent as compared with more than 11 per cent in the adult[2] In the case of babies absorption is even more complete the difference being to a large extent due to a more perfect absorption of the inorganic constituents, the reason for which is the greater demand for calcium salts in the infant This reacts favourably on the absorption of the fat of the milk, for unabsorbed calcium salts are apt to form insoluble soaps with the fat, and so hinder its absorption

The *comparative absorption of boiled and unboiled milk* has been the subject of a good deal of experimental investigation Taking the whole of the evidence the conclusion seems to be justified, that just as boiling does not appreciably diminish the digestibility of milk in the stomach, so it does not to any important extent interfere with its absorption in the intestine One need have no fear, therefore, that the great advantages of boiling are purchased at the cost of any noteworthy diminution of digestibility or absorption[3]

Two other points relating to the behaviour of milk in the intestine call for mention The first is that milk seems to be absorbed with less expenditure of energy—that is to say, with less wear and tear upon the part of the intestine than any other food (Pavlov) This no doubt explains in part the great value of milk diet in many intestinal diseases

The other point is that milk seems to exercise a restraining influence upon putrefactive processes in the intestine The explanation of this, whether it is to be attributed to the casein or to the influence of acids produced from the milk sugar, is still disputed, but of the fact there appears to be no doubt

NUTRITIVE VALUE OF MILK

It is frequently said that milk is a perfect food Now, this is an exaggeration There is no such thing except theoretically as a perfect food But milk does come very high on the list of all

[1] See RUBNER and HEUBNER (1898) *Zeit f Biologie* 36, 1, UFFELMANN (quoted by Marcuse) (1896) *Pflüger's Archiv* 64 223 CAMERER. (1880) *Zeit f Biologie* 16, 493

[2] PRAUSNITZ (1889) *Zeit f Biologie* 25 533

[3] Experiments on young rats (*Journ Hygiene* 1909 9, 233) showed no diminution in the nutritive value of milk when boiled, or even when evaporated and dried

far more high spirited and irrepressible, being often in trouble on that account

'Furthermore, during the winter of 1923–4 there was complete absence of illness among the boys with the milk ration, although in other houses the sickness rate had been somewhat higher than usual owing to naso respiratory catarrh (influenza) and to a limited outbreak of measles and scarlatina

Confirmatory observations made on groups of school children in Scotland [1] showed that an addition of ¾ to 1 pint of milk to the daily diet caused a rate of growth and weight 20 per cent higher than that of children who did not receive extra milk or who were given its Calorie equivalent in the form of biscuits Separated milk (machine skimmed) was found to be quite as effective as whole milk which confirms the high opinion of its value already expressed

Milk as an article of diet in disease occupies a unique position No single food it may safely be said is of so much value The drawbacks to its exclusive use in health, which we pointed out above, are now of no account or are even converted into advantages The use of milk in the dietary of different diseases will be considered in detail in a subsequent chapter, but some of its general properties may be mentioned here

Being a fluid, it is easily swallowed This is a great gain to exhausted patients For the same reason the quantity given can be simply regulated and measured Its fluid form also enables it to be used in place of other beverages and a glass of milk with each meal is one of the simplest prescriptions for increasing the amount of food a patient is taking It is often recommended to people who require to be fattened

The amount of water it contains makes milk a means of quenching thirst as well as of supplying food It is therefore grateful to feverish patients

Its bulk is no serious drawback in most illnesses A patient at rest and warm in bed requires much less food than an active man and may even gain weight on 3 or 4 pints of milk per day although more than twice that quantity may be requisite when up and about In addition to this concentrated foods are not so well borne in severe disease and a moderate degree of dilution is an advantage Milk calls for less secretory effort and is more easily absorbed than any other food and this marks milk as a food of special value in gastro intestinal disorders To these advantages are added the facts that milk contains none of the "stimulating substances found in meat and no purine bodies From the earliest times

[1] Orr (1928) *Brit Med Journ* 1, 140 (1929) *ibid* 1, 161

great value in the dietary of persons to whom economy is of importance cannot be overestimated It is in carbohydrate that milk is specially deficient Hence it should be used chiefly in conjunction with other foods rich in that ingredient Such a food is bread Bread and milk sufficient to give 1000 Calories costs approximately one eighth of what a lunch to supply the same would cost at a cheap restaurant

The claims of skim milk to be regarded as a valuable source of food are fully justified, and should be carefully considered by all who are responsible for drawing up an ample and economical dietary for large numbers of persons—such, for example as the inmates of public institutions During the year 1943 the students of one of us (V H M) discovered that rarely did the canteens and institutions they investigated make full use of the "household milk" which was available, or indeed of dried eggs thus neglecting an admirable source of first class protein and calcium

Unfortunately, the prevailing tendency is to regard milk as a beverage rather than as a food This is a great mistake, in proof of which we cannot do better than quote Dr Corry Mann's classical work on "Diets for Boys during the School Age"[1] This was an experiment, lasting in all three years, on the influence on growth in height and weight of a carefully selected and scientifically controlled group of English boys between the ages of 7 and 11 years, of the addition each day to their diet, of one pint of pasteurized and homogenized milk A group of 41 boys in the first 12 months gained an average of 6 98 lb per boy and grew an average of 2 63 in in contrast with the control figures of 3 85 lb and 1 84 in respectively This increased rate of growth was no "flash in the pan" but was maintained even into the third year of the experiment No other food added in control experiments produced anything like so great an increase, though it may be noted that the addition of New Zealand butter was distinctly advantageous

Apart from the marked gain in weight and height there was a general improvement in their physical condition—a loss of tendency to chilblains to roughness of skin, and to lordosis "After eighteen months" the report states, "a casual visitor entering the dining hall, where the boys of nineteen houses sit at table, would never fail to recognize the table of that house which was alone receiving the extra ration of milk the boys of that house being obviously more fit than those of any other house" In addition they became

[1] CORRY MANN (1926) *Med Res Council Report* No 105 CHANEY (1923) *Amer Journ Dis Child* 26, 337 MORGAN HATFIELD and TANNER (1926) *ibid* 32, 837 MCCOLLUM ORENT KEILES and DAY (1939) *The Newer Knowledge of Nutrition* Fifth Edition

than any other form of food and has been recommended in delirium tremens" [1]

Casein Preparations

In practical dietetics, the want of a tasteless compact, easily digested and moderately cheap preparation of pure protein is often felt Caseinogen is admirably adapted to meet these requirements and has now been separated from milk and introduced as a dietetic preparation on its own account The preparations known as Plasmon Casumen, etc, are examples of caseinogen prepared in various ways They contain about 80 per cent of protein

In these forms caseinogen is digested with ease and absorbed almost in its entirety and is capable if necessary, of replacing all other forms of protein in the diet Added to this caseinogen presents some special advantages not possessed by other varieties of protein. For one thing it is readily capable of fixing acids, and so neutralizing them The power of caseinogen in this respect is three times greater than that of an equal weight of beef This property gives it special advantages in those cases of dyspepsia in which too much acid is being poured into the stomach

Caseinogen is a phosphoprotein, contains all the essential amino acids though its content of cystine and methionine is low, is easily digested and absorbed It forms no clot in the stomach Its main defect is that it contains but little calcium though much phosphorous for it is usually prepared by acid precipitation and not by rennin

The nutritive value of these preparations of caseinogen is undoubtedly very high, for they contain fully 80 per cent of pure protein An invalid does not require more than 80 grammes of protein daily and this quantity would be covered by 100 grammes (3½ oz) of Plasmon or Casumen That an amount almost equal to this can be administered daily for prolonged periods has been fully proved by clinical experiment

It is as a means of enriching the diet in protein rather than as sources of energy, that these preparations are specially valuable Roughly speaking one may say that one part of them is equal as a source of protein to four parts of meat Their tastelessness and solubility enable them to be added to other foods, such as soups milk puddings cocoa and jellies raising greatly their nutritive value and without the patient s being aware that any such addition has been made In many cases of illness and especially, perhaps in fevers they increase very considerably our dietetic resources

[1] *Food and the Principles of Dietetics* Eighth Edition

Butter milk is very easily digested owing to the absence of fat and to the fact that its casein is present in a finely flocculent form

Its nutritive value is considerable, an ordinary glassful yielding about as many Calories as 2 oz of bread It is as a cheap source of protein, however, that butter milk is chiefly deserving of notice In respect of this constituent, it is not one whit inferior to ordinary milk, and yet butter milk is usually thrown out to the pigs There can be no question that there is here a great waste of a very valuable food When used in large quantities, butter milk has diuretic properties which may be a slight disadvantage in health, but would rather enhance its value than otherwise in many cases of disease

Soured Milks Kephir, Koumiss, etc

The preparation of these milks is dealt with elsewhere and a more detailed account will be found in an earlier edition Apparently little interest has been taken in these commodities for years in the analytical world We append analyses as quoted in earlier editions and in Schall

	Protein	Fat	Lactose	Alcohol	Mineral Elements	Lactic Acid
Koumiss (Rubner)	2 2	2 1	1 5	1 7	0 9	0 9
Kephir (Rubner)	3 1	2 0	1 6	2 1	0 8	0 8
Butter milk (Rubner)	3 8	1 2	3 3	nil	0 6	0 3
Yoghurt (Schall)	3 3	2 8	3 1	nil	not given	0 8

These substances are reputed to be more digestible than the respective milks from which they arise The caseinogen is in a fine flocculent form The carbon dioxide in the fermented drinks (Koumiss and Kephir) is supposed to break up the curd in the stomach The alcohol is not enough to cause more than a mild hilarity, with no subsequent headache And the taste is pleasant to those with a conditioned reflex for it

There can be no harm in taking it and though we know of no recent instance in which its use has proved of advantage it has been recommended as of value in all conditions of impaired nutrition, in continued fevers and in convalescence It may also be used in chronic catarrh of the stomach or bowels, in cases of hepatic cirrhosis, and in renal disease It is often better borne in vomiting

than any other form of food and has been recommended in delirium tremens"[1]

Casein Preparations

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[1] *Food and the Principles of Dietetics* Eighth Edition

and have taken an important place in treatment They are superior to meat preparations as condensed forms of protein

There are various preparations of caseinogen combined with glycerophosphate of sodium on the market (Sanatogen, Kemposan, Nervogen) In virtue of their casinogen these have the same nutritive value as the other preparations considered above The organic phosphorus in them appears to be fully assimilated It may be doubted however, that they have a "specific tonic effect on the nervous system"

Cheese

Of cheese there is an infinite variety They have this in common they contain the casein, some or all of the fat the vitamin A, the calcium and phosphorus and some of the vitamins B_1 and ribo flavine of the milk from which they are made The majority are made from cows milk, but some are from goats' and ewes milk Cheese is a mode of preserving much of the food value of milk in a condensed form for long after the milk from which they are made would be unfit for consumption For example, Cheshire cheese is at its best about a year after it is made Because of the strong flavours developed in cheeses under the influence of bacteria and moulds cheese is often regarded more as a condiment than as a staple food, but this is to be deprecated Cheese is one of the most valuable foods there is and is a most convenient way of spreading the excess of milk in early summer in a concentrated form over the whole year

It is prepared mainly in two ways Milk, with or without pasteurization, is directly treated with rennet to produce a clot, or the milk may first be soured by means of a starter after pasteurization and then clotted with rennet The first way produces a sweet curd and the second an acid curd Cheeses from an acid curd have much better keeping qualities Stilton is an example of sweet curd cheese and Cheddar and Roquefort of acid curd cheeses

Instead of using a starter, the milk may be allowed spontaneously to sour or acids added to bring down the caseinogen In all cases the casein clot or caseinogen curd entangles the fat The milk may be enriched by the addition of cream (Stilton) or it may first be skimmed in which case the fat content of the cheeses will be low and the protein percentage increased (Dutch and German cheeses) So even at the first stage of cheese making individual variations of the finished product are instituted Where starters are used it is important to control the nature of the bacteria they contain—usually streptococci lactis or cremoris—for they are

susceptible to invasion by bacteriophage, which slows the production of acid and thus effects a loss of keeping quality and flavour

After the clot has fully formed it is cut with special knives This liberates the whey from the curd, and the mass may be both stirred and warmed, allowed to settle and the whey run off The curd is eventually ground in a mill salted and put into moulds The remainder of the whey may be squeezed out under pressure. This produces a *hard cheese* e g Caerphilly Cheddar Cheshire Gloucester, Parmesan But where the whey drains out under the natural weight of the curd, a soft cheese results e g Camembert Gorgonzola and Stilton. The soft cheeses do not keep well and are intended for early consumption the hard cheeses are at their best in the course of a year The soft cheeses are of an open texture and moulds from the air make their way into the interior (Stilton, Blue Vinny, Rocquefort and Gorgonzola) This is often aided even with Stilton by pricking the cheese e g Roquefort The amount of salt the time at which it is added and the date of pricking also determine the rate and mode of ripening and the differences between Roquefort and Danish Blue on the one hand and Stilton and Gorgonzola on the other From the lactic acid present in the curds and from the fat, volatile fatty acids are formed (acetic propionic, butyric and caproic), and also from the fat higher non volatile fatty acids These help to determine the flavour Sharpness is due to acetic and propionic compounds cheesiness to butyric and valeric compounds and pungency to caproic caprylic and capric bodies Moreover there is degradation of the protein, with ammonia production which adds to the flavour of the cheese In view of the varied nature of the processes by which cheese is made and the complexity of the biological and chemical reactions within the cheese as it ripens, we can understand the reason why there is such an infinite variety of cheeses and why even cheeses of one type vary so much one from another This has been particularly noticeable in war time cheese' which has often been inefficiently made and rushed on to the market before it had achieved a venerable ripeness [1]

The value of cheese in nutrition is judged by its content of protein, fat, calcium, phosphorus and vitamin A. The following analyses are taken from McCance and Widdowson [2]

[1] For the technology bacteriology and flavour of cheeses a number of papers given to the Food Group of the Society of Chemical Industry should be consulted KAY (1941) *Chem and Ind* 60, 411 HISCOX. (1941) *ibid*, 60, 563 MEANWELL (1943) *ibid* 62, 73 WAYGOOD (1943) *ibid* 62, 59

[2] *Chemical Composition of Foods* (1942) *Med Res Council Special Report* No 235 Third Edition

	Protein	Fat	Carbo hydrate	Cal cium	Iron	Phos phorus	Calories per oz
				mg	mg	mg	
Cheddar	24 9	34 5	trace	810	0 57	545	120
Cream (home made)	3 2	86 0		29 6	0 14	44	232
Dutch	28 1	16 8		900	0 78	478	77
Gorgonzola	24 8	31 1		540	0 50	375	112
Gruyère	36 8	33 4	,	1080	0 26	698	131
Packet'	22 5	30 1	,	724	0 57	480	106
Parmesan	34 4	29 7	,	1220	0 37	772	118
St Ivel	23 1	30 5	,	483	0 72	375	108
Stilton	25 1	40 0	,	362	0 46	304	135

The vitamin A potency of cheese" (i e Cheddar type) is given by the Medical Research Council as 1300 I U per 100 grammes, the vitamin B_1 as 30 microgrammes (or 10 I U), and riboflavine as 500 microgrammes These are average figures and vary with the source of the milk and the time of the year Kay[1] comparing Cheshire cheese made from winter milk with that from summer milk, showed that the former gave only about 700 I U vitamin A activity per 100 grammes while the summer milk cheese yielded approximately 1500 I U The relatively high amounts of riboflavine which he found in winter and summer milk cheeses (280 microgrammes and 350 microgrammes respectively) must be due to a combination of protein with the riboflavine The low figures for calcium and phosphorus in Stilton cheese is due to the removal of those substances by the lactic acid of the whey which is allowed to bathe the curd for a long time A large proportion of the calcium and phosphorus of Stilton migrates to the crust, is deposited there, and when the cheese is eaten is thrown away with the crust

Digestibility The infiltration of cheese with fat must always render it an article of diet not easily dealt with by the stomach, for the fat forms a waterproof coating, which prevents the access of the digestive juices to the casein

The larger the lumps of cheese which reach the stomach, the slower will this access be Hence the importance of reducing the cheese to a state of fine division before it is swallowed This may be done by careful chewing Now, it is more easy to pulverize a hard morsel than a soft one, for the latter always tends to elude the teeth For this reason, a piece of hard dry cheese is more easily

[1] KAY (1941) *Chem and Ind* 60, 411

digested than a soft and moist piece A better plan however is to break up the cheese before it is eaten This may be done by grating and so successful is this that it can be given in this form to infants of nine months of age!

A possible reason for its reputed indigestibility is that it is taken at the end of a meal and its strong odour flavours any subsequent eructations Any other highly flavoured food would do the same

It is only in the stomach that the difficulty of digesting cheese occurs, once in the intestine it is absorbed very thoroughly over 90 per cent of the protein being retained in the body, and nearly 90 per cent of the energy it contains being available'[1]

Nutritive Value Of the high nutritive value of cheese there can be no doubt It is just what would be expected when one remembers that a pound of say Cheddar cheese represents the total casein and vitamin A most of the fat and calcium and a quarter of the riboflavine in a gallon of milk or 2 oz cheese results from 1 pint of milk

The average amount of moisture which cheese contains is 33 per cent the remainder being made up of protein and fat in varying but on the whole fairly equal proportions The amount of water in moderately lean beef is about 73 per cent the remainder being also made up of protein and fat, the former usually predominating

Beef then contains less than half as much nutriment as the same weight of cheese It has been calculated that a cheese of 20 lb contains as much nutriment as a sheep s carcase of 60 lb Moreover cheese is almost the best source of calcium and phosphorus A vegetarian who took all his animal protein as milk and cheese had the large amount of 2 grammes of calcium per day in his diet[2]

An appeal to the standard of the Calorie gives the same verdict A pound of cheese yields nearly 2000 Calories of energy which is more than three times the amount yielded by a pound of moderately lean beef Furthermore a pound of cheese can be obtained at about one quarter of the cost of a lb of beef which is its nutritive equivalent and therefore it is at once evident that cheese is a substitute for meat which should be of the greatest value in poor households

But if cheese is thus to become a cheap substitute for meat it is of the greatest importance what variety of cheese is bought For it is true of cheese in an even greater degree than of most other foods that in buying it we pay for flavour not for food value In the

[1] U S Dept of Agriculture Farmers Bull. No 487
[2] WIDDOWSON (1936) *Journ Hygiene* 36, 269

9th edition this point was driven home by the calculation of the cost per unit of nutriment obtained from different cheeses, but as many of those listed will not be procurable for many years to come, it would be useless to quote or attempt to recalculate them now It must suffice that in 1939 the cost ranged from 1s 4½d, for "American' Cheddar to 4s 2d for St Ivel This high price for flavour and convenience is particularly marked in the cheese labelled "packet" cheese in the table given above These cheeses are usually manufactured from matured cheeses of the Cheddar type which have been milled, melted and mixed with milk and the whole pasteurized They have an individual flavour, constant texture and remarkable keeping quality

Finally, the biological value of the protein in cheese is high, though not as high as that of the mixed proteins of milk Henry and Kon[1] obtained by the method of Mitchell a biological value of 75 for the proteins of Cheddar cheese and demonstrated a marked supplementary relationship between them and those of white bread But to show that supplementary action they must be taken together —as indeed is the usual custom !—and not separated by 24 hours Moreover the proteins of cheese contain valuable amounts of the important amino acid, methionine

Cheese then, is a food the consumption of which is to be encouraged, not as a condiment or savoury at the end of a meal, but as a *piece de resistance* It is portable, compact and highly nutritious 4 oz cheese, 8 oz of National Wheatmeal bread and 2 oz watercress form an almost nutritionally complete meal Only vitamin D is missing though its precursor, cholesterol is present and it yields 1000 Calories During the war of 1939–45 the agricultural labourer has been allowed a ration twice or more as large as the normal individual—a welcome recognition by the Ministry of Food of its value in diet Oddly enough taste varies markedly in different parts of the country and in different strata of society The Welsh miner for example, readily consumes cheese but the Durham miner will not touch it There is room for propaganda in favour of cheese

FISH[2]

Chemical Composition —Protein and fat are the chief nutritive constituents found in fish According to the relative proportions

[1] HENRY and KON (1942) *Chem and Ind* 61, 97

[2] In preparing this section the writers have derived much help from the following publications ATWATER W O (1891) *The Chemical Composition and Nutritive Values of Food Fishes and Aquatic Verte*

of these ingredients present fish may be conveniently divided into two groups of "fat" and "lean"

The fat fish have considerable amounts of fat in their flesh, say from 10 per cent upwards They are bloaters eel herring kippers salmon, sardines sprats and whitebait The lean fish have almost negligible amounts of fat say about 1 per cent or under They are cod, flounder, haddock, John Dory, lemon sole ling megrim, monkfish plaice pollack, saithe sole, stockfish turbot and witch It is true that there are some with intermediate amounts such as bass, bream brill, catfish, gurnet hake, halibut, mackerel mullet, pollan, sturgeon and trout but the amount of fat is rarely as high as that of lean meat

Analyses of some of the commoner varieties are here given

COMPOSITION OF FISH (RAW) (Plimmer)

	Protein	Fat.	Calories per oz	Carbo hydrate
Cod	14 6	0 1	17	0
Eel	8 7	15 1	50	0
Haddock	12·0	0 2	14	0
Herring	11 6	8 8	40	0
Mackerel	11·0	6 2	29	0
Plaice	7 7	0 7	11	0
Salmon	14 7	12 5	50	0
Smelt	11 3	1 6	17	0
Sole	13·0	1 3	19	0
Turbot	8 8	1 3	12	0
Whiting	11 3	0 1	12	0

When steamed or boiled there is a considerable concentration of nutrient material for the protein shrinks in volume and squeezed out water This is evident from the following table based on McCance and Shipp [1] though the figures are not quite comparable being obtained by different methods and from materials from a different part of Great Britain

[1] *op cit*

brates Washington (abstract from Report of U S Commissioner of Fish and Fisheries 1888) LANGWORTHY C F (1898) *Fish as Food* U S Dept of Agriculture Farmers Bull 85 MCCANCE R A and SHIPP H L (1933) *The Chemistry of Flesh Foods and their losses on Cooking Med Res Council Special Reports* No 187 MCCANCE and WIDDOWSON (1942) *The Chemical Composition of Foods Med Res Council Special Reports* No 235 3rd edn.

Analysis of Flesh of Cooked Fish

	Protein	Fat	Carbohydrate	Calcium	Iron	Phosphorus	Calories per oz
				mg	mg	mg	
Cod steamed	18 0	0 9	0	14 6	0 5	242	23
Eel stewed	11 0	18 1	0	41 7	1 2	137	60
Haddock, steamed	22 0	0 8	0	54 6	0 7	234	28
Halibut	22 7	4 0	0	13 0	0 6	255	37
Herring baked	16 9	12 9	0	58 2	1 6	326	54
Plaice steamed	18 1	1 9	0	37 7	0 6	246	26
Salmon ,,	19 1	13 0	0	28 9	0 8	302	57
Sole ,	17 6	1 3	0	113 0	0 7	270	24
Turbot ,	20 7	1 6	0	13 5	0 5	188	28
Whiting	19 9	0 9	0	42 0	1 0	180	26

To these may be added some analyses of preserved fish

Preserved Fish as purchased

	g per 100 g			mg per 100 g		Calories per oz
	Protein	Fat	Carbohydrate	Calcium	Iron	
Bloater	12 6	10 5	0	84	1 4	41
Cod hard dried	27 3	1 0	0	43	1 6	34
Haddock smoked	9 9	0 3	0	47	0 6	12
Kipper	11 4	16 0	0	72	1 2	37

Preserved Fish as served

	Protein	Fat	Carbohydrate	Calcium	Iron	Phosphorus	Calories per oz
Bloater grilled	22 5	17 4	0	123 0	2 2	355	73
Cod dried, soaked 24 hours and boiled	32 0	0 9	0	22 4	1 8	163	40
Haddock, smoked steamed	22 3	0 9	0	57 5	1 0	213	29
Kipper	23 2	11 4	0	64 8	1 4	426	57
Salmon tinned	19 7	6 0	0	66 4	1 3	285	39
Sardines ,	20 4	22 6	0	409 0	4 3	683	84

The points in the composition of fish deserving of comment are these

1 There is a large amount of waste in the form of bones skin, etc As sold the waste may be as much as 70 per cent while even in fish as served at table it may be 35 per cent This increases its cost in transport when compared with meat
2 Fish especially the leaner varieties have a high water content—considerably more than lean meat
3 Fish contains more gelatin than meat and this is largely lost when fish is boiled—a reason why this method of cooking is by no means advantageous
4 Fish is poor in extractives and lacks flavour compared with meat and so a fish diet is apt to prove monotonous
5 The Calorie value of fish is low except in the fat fish
6 Fish is a good source of protein though not so good as meat or cheese
7 With the exception of sole and of those fish in which it is impossible not to eat some of the bones (bloaters herring kippers sardines sprats and whitebait) fish is a poor source of calcium though an excellent source of phosphorus
8 Their content of purine bodies run as high as or higher than those of meat

In spite of these drawbacks when compared with meat, it forms a very valuable addition to our diet and it is absurd that with the methods of refrigeration at our disposal and the excellent fishing grounds near the coasts of the British Isles such a source of good protein should be so difficult to obtain in most inland parts of this country Moreover fish is one of the best sources known of nicotinic acid and the fat fish are a good source of vitamins A and D Herrings and herring roes are the cheapest source of animal protein and it should be the task of dietitians to stimulate a demand for fish and of enterprising firms to put fish on the market in a fresh condition Fortunately the conditions for preserving the good qualities of fish have been worked out at the Torrey Research Association Fish after six days storage in an ordinary ship are stale and after twelve days when stored in ice If fish are frozen in iced brine at $-4°$ F and kept at that temperature they are still good after six months White fish frozen at $-22°$ F while still in *rigor mortis* are more satisfactory at the end of eight months than most of the fish now sold on the open market Herrings can be brought to freezing plants *on shore* while still fresh, can be stored

there many months and then kippered or packed, obviating the difficulty of gluts Finally, fish can be dehydrated and, when packed in containers filled with nitrogen, remain good for a year The presentation of satisfactory fish and fish products to the public is a question of organization and capital [1]

Digestibility of Fish The white or lean fish are reputed to be digestible, whereas the fat fish are not There is no doubt that they are easy to chew, have but very short bundles of muscle fibres and when cooked fall easily to pieces They are consequently used in the diet of the very young the very old the dyspeptic, and the convalescent

None the less experiment is not so very much in favour of their extreme digestibility Hawk, Rehfuss and Bergeim in 75 observations on the normal human stomach find that while fish evoke a slightly greater flow of acid they leave the stomach but slightly faster than beef and beef products [2] For the present we must rely more on clinical observation than upon scientific experiment It is strongly in favour of the digestibility of the white fish Cod seems to be an exception, having a coarse fibre, and its comparative indigestibility, as found by Chittenden and Cummins is by no means in contradiction with actual experience (Pavy) The slow solution of salt fish is fully explained by the hardening of the fibres which salting produces

The *absorption of fresh and smoked fish in the intestine* takes place quite as well as that of meat about 95 per cent of the total solids, 97 per cent of the protein and 90 per cent of the fat entering the blood (Langworthy) Salted and dried fish are not quite so well absorbed [3]

Nutritive Value of Fish The value of fish as a source of energy depends entirely on the amount of fat which it contains The fat fish such as salmon are fully equal to moderately fat meat in this respect while the lean fish, owing both to the absence of fat and the presence of more water, are of considerably lower nutritive value It may be reckoned that 2 lb of cod or other white fish are only equal in nutritive value to 1 lb of lean beef

Fish can however, be made to take up a considerable amount of fat in the process of cooking and so have its nutritive value greatly increased This is shown in the following table

[1] See *The Problem of Supply of Sea Fish in an Industrialised Country* (1944) *Food Manufacture* iv, 347 and SHEWAN (1945) *Chem and Ind* 98

[2] *Amer Journ Med Sci* (1926) 171, 359

[3] SLOWTZOFF (1910) *Zeit f Physik und diat Therapie* 15, 22

AVERAGE COMPOSITION OF EDIBLE PORTIONS OF 15 ASSORTED WHITE FISH (1) STEAMED and (2) FRIED IN BATTER and BREADCRUMBS (MCCANCE AND SHIPP)

	Water	Protein	Fat	Carbohydrate	Calorie Value per Ounce
(1) Steamed	[illegible]	22 4	1 38	0 0	32 0
(2) Fried	61 5	19 3	11 9	6·4	61 4

As a source of building material fish is somewhat inferior to lean meat owing to the smaller amount of protein which it contains This statement applies more strongly to lean fish than to the fatter varieties Owing to this smaller proportion of protein and in part also in all probability to its lesser richness in extractives fish seems to be a less stimulating food than meat For the same reasons white fish may sometimes be used with advantage instead of meat by sedentary persons and in hot weather

Two special qualities are erroneously attributed to a fish diet by popular fancy We refer to the beliefs (1) that fish is specially valuable as a brain food (2) that it possesses aphrodisiac qualities The false bases for these beliefs are dealt with in earlier editions of this work

Economic Value of Fish The market price of fish is no indication of true economic value Although such fishes as haddock and sole are of practically the same nutritive value yet the price of the latter may be three times that of the former On the other hand it by no means follows that none of the dearer varieties of fish is worth the money Salmon, for example yields three times as many Calories as an equal weight of cod, and thus a pound of the former at 3*s* 6*d* may not really be any dearer than a pound of cod at 1*s* 2*d* The amount of waste in fish is also of great importance from the economic point of view We have seen that the inedible parts of fish as purchased may amount in some cases to as much as 70 per cent of the whole and allowance must be made for this in calculating the real cost For this reason it may be worth while to pay a rather high price for canned fish for in these preparations almost the whole of the material paid for is in an edible form It is a matter for exact calculation

As a general rule it may be said that the cheaper varieties of the fat fishes offer most nutriment for any given sum Salted white fish probably rank next to these An average herring contains about 15 grammes of edible protein ($\frac{1}{2}$ oz) and from 5 to 10 grammes of fat and it has been remarked that the despised bloater offers the largest amount of nutriment for a given sum of any animal food [1]

[1] This is not quite true Fresh herring and herring roes run a neck and neck race with Australian and New Zealand cheese in peace time for cheap animal protein

and three salt herrings contain as much animal protein as need enter the daily dietary of an ordinary working man

The justice of these remarks is borne out by the following calculations

COMPARATIVE COSTS OF PROTEIN AND ENERGY AS FURNISHED BY DIFFERENT KINDS OF FISH

	Cost per lb [1]		Cost per ration of First class Protein [2]		Cost per 1000 Calories [2]	
	s	d	s	d	s	d
Cod (section)	1	0	0	6¼	3	7½
Haddock (fresh)	0	10	0	6¼	3	7
Hake	1	4	0	11	6	6½
Halibut	1	6	0	11	6	5
Herrings	0	6	0	3½	0	9½
Mackerel	0	7	0	9½	1	3
Salmon	3	0	1	[illegible]	3	9
,, *(Newfoundland)*	1	8	0	11	2	1
Soles	2	2	1	4½	7	2½
Turbot	2	4	2	6	10	8

The relative cheapness of cod haddock and herrings for protein and of herrings for Calories will be manifest, otherwise fish are moderate to expensive for protein and extravagant for Calories

Of the "offal" of fish, the ovary or *roe* [3] is alone commonly eaten The roe of the sturgeon, when highly salted, constitutes caviare, the best forms of which come from Astrachan Good *caviare* should be of a greyish colour—not black—and one should be able to make out the separate eggs in it quite easily It is packed in vessels made of lime wood as it is very apt to take up foreign flavours and of these lime wood is destitute The composition of caviare is as follows (Langworthy)

Water	[illegible] 1 per cent
Protein	30 1
Other non nitrogenous matters	7 6
Fat	19 7
Mineral elements	4 6
Fuel value per lb	1530 Calories

The proteins contain a good deal of nuclein the significance of which as an article of diet has already been mentioned (p 254)

[1] These are 1939 prices at a high class store The figures will have to be recalculated so soon as prices settled to a new level after the war It is unlikely however that the relative positions will change greatly though the actual figures undoubtedly will

[2] Calculated on Plimmer s Analyses

[3] Usually called the hard roe

Three ounces of raw salted caviare are digested in the stomach in about two hours.

The *milt*[1] is the organ in male fish corresponding to the roe and resembles the latter very closely in composition and nutritive value. Plimmer's figures for the herring soft roe are: Protein 20.0 per cent., Fat 3.6, Mineral elements 3.0, Calories per oz. 40.0. McCance and Widdowson's figures for fried roes are Protein 23.4, Fat 15.8, Carbohydrate 4.7, Calcium 15.7 milligrammes, Iron 1.5, Phosphorus 515 milligrammes, Calories per oz. 74. (The roes were rolled in flour before frying.) The milt, however, is much richer in purines. (Purine N in herring milt is 0.481 per cent.)[2]

The lobster, crab and other crustaceans, the molluscs such as the oyster and mussel, and the turtle and frog amongst reptiles and amphibians may conveniently be considered at this point.

The *lobster and crab* both consist of two distinct parts: the flesh, which is contained in the claws and tail, and the body, which is mainly made up of liver. The general composition of these parts is thus contrasted by Payen:

PERCENTAGE COMPOSITION OF LOBSTER AND CRAB

	Flesh	Body
Water	76.6	84.31
Protein	19.17	12.14
Fat	1.17	1.14

COMPOSITION OF TINNED LOBSTER (Langworthy)

Water	77.8 per cent
Protein	18.1
Fat	1.1
Carbohydrates	0.6
Mineral elements	2.4

The composition of the crab and the prawn is practically the same.

The flesh of the lobster and crab is rather indigestible, mainly on account of the density and coarseness of the fibres and the thickness of their walls. The use of vinegar helps to soften the fibres besides neutralizing ammoniacal salts which are apt to be present.

The body of these animals is also prone to disagree, not only from the fat which the liver contains, but also because a number of unfortunate people are sensitive to their proteins and develop allergic diseases after eating them.

[1] Usually called the "soft roe."

[2] Cod's roe purine Nitrogen is 0.130 per cent.

Three ounces of potted lobster require about two and a half hours for digestion in the stomach

The *oyster* is the most typical and popular of the molluscs Chemically it contains within itself representatives of all three nutritive constituents of the food

AVERAGE COMPOSITION OF OYSTERS (McCance and Widdowson)

Nitrogenous substances	10 2 per cent
Fat	0 9
Carbohydrates	Trace ,
Calcium	0 186
Iron	0 006 ,,

Glycogen is the form in which carbohydrate is present in oysters It is contained in the liver In addition oysters are rich in vitamins and in mineral constituents, including iodine iron and copper[1]

The oyster is rightly regarded as an easily digested food—at least, if taken raw Three medium sized oysters are entirely disposed of by the stomach in 1¾ hours Cooking renders them tough and less easily digested

The nutritive value of oysters is not high A dozen Ostend oysters contain about 5 grammes of digestible protein and 1½ grammes of fat It would take fourteen of them to contain as much nourishment as one egg and 223 to equal a pound of beef (Stutzer) It is therefore not surprising to hear of enormous quantities of oysters being occasionally consumed at a sitting They are an extravagant form of food for a day s ration of first class protein on Plimmer s analyses costs no less than £1 2*s* 4*d* when oysters are 3*s* 6*d* a dozen

The belief that oysters may be the means of conveying the infection of typhoid fever is not unwarranted, for if oysters are grown in estuaries they easily enough become infected with typhoid germs derived from sewage, and it has been found by artificial inoculation that typhoid bacilli thus introduced are capable of surviving in the body of the oyster for several days[2] The risk, however, can be avoided by keeping the oysters alive for a day or two in salt water which is frequently changed This washes them out and destroys the bacilli Cooking effects the same object with greater certainty, but at the cost of diminished digestibility Modern English oyster beds are very carefully inspected and kept free from contamination

[1] L BINET and M V STRUMZA (1933) *Paris Med* July 1st III The iron is 6 milligrammes per cent according to McCANCE and WIDDOWSON *op cit*

[2] HERDMAN and BOYCE *Lancashire Sea Fisheries* Memoir II ' Oysters and Disease '

The composition of mussels, clams, periwinkles, scallops, and other molluscs is very similar to that of the oyster, and, like the latter, they cannot be regarded as foods of important nutritive value, though they do contain very significant amounts of calcium and iron. They rarely cause digestive disturbance, but unfortunately some people are sensitive to one or other of these shell fish. They may develop urticaria or they suffer from vomiting and diarrhœa. These latter symptoms are sometimes very severe and may cause death. It is possible that they are due to decomposition taking place as a result of storage.

The *green turtle* is almost the only reptile used for food in this country, and that chiefly in the form of soup. It is called green because its "fat" has a greenish colour, which, according to Sir Hans

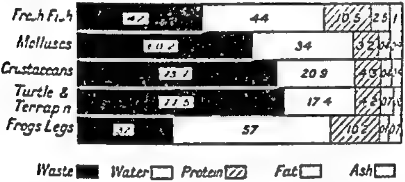

FIG. 20.—COMPARATIVE COMPOSITION OF FISH AND THEIR ALLIES

Sloane, imparts a yellow tint to the sweat of those who partake largely of it. In preparing the soup, the dorsal and ventral shields are removed, scalded to remove the scales, and then boiled till the bones separate. The liquor forms the stock. The softer parts of the shield are then cut into oblong pieces which constitute the so-called lumps of "green fat"—really a species of cartilage. Sun-dried turtle forms a soup of equal nutritive value, and at a considerably lower cost, while the basis of mock turtle is the gelatinous substance in the scalp of the calf. From a strictly nutritive point of view, turtle soup is certainly not worth a tenth of the price paid for it.

Frogs' legs are but rarely seen in this country, though common articles of diet on the Continent and in the United States. They are derived from the large edible frog (*Rana esculenta*), and though easily digested and of a delicate flavour, are not of high nutritive value.

The average chemical composition of the different groups of foods

studied in this section is represented in Fig 20, which also gives some idea of their relative nutritive values It is constructed from the analyses published by Langworthy

MEAT

Most of what we call meat is muscle—the muscles of the animal killed which enabled it to ' move and have its being ' Even tripe is mainly muscle, and so is the edible portion of heart, though brain, liver and kidneys, of course, are not This is no ground for believing that meat is especially good for the manufacture of human muscle though there may be something in this line of argument The distribution and relative amounts of *amino acids in its proteins* are very like those of human muscle

Physical Structure We may look first at the physical structure or architecture of meat (Figs 21 and 22) If one examines a piece of boiled meat, it will be found that it can easily be torn into a number of long stringy fibres On microscopic examination these are found to be made up in their turn of bundles of microscopic tubes, known to the histologist as muscle fibres The bundles of *fibres vary in length in different kinds of meat* Sometimes they are short, as in the breast of a chicken, at other times they are much longer, as in the leg of a crab, and the shorter they are the more tender and easily digested the meat is Meat should be cut or carved at right angles to the long axis of the fibres It is then more easily chewed, and the contents of the tubes being exposed, the flavour is increased, while the action of the digestive juices is facilitated

The walls of the tubes consist of a protein substance (elastin) while the connective tissue which holds together the fibres is chiefly composed of a material called ' collagen, which yields gelatin on boiling The older an animal is and the more work its muscles have had to perform the denser is the connective tissue and the thicker the walls of the tubes The latter fact was long ago pointed out by Dr Kitchiner in his *Cook s Oracle* 'That exercise produces strength and firmness of fibre,' he says is excellently well exemplified in the woodcock and partridge The former flies most the latter walks the wing of the woodcock is always very tough of the partridge very tender hence the old doggerel distich

> If the Partridge had but the Woodcock s thigh
> He d be the best bird that e er doth fly '

Embedded in the connective tissue between the fibres is a variable amount of fat Sometimes it is almost entirely absent—e g in most

forms of game and in the breast of the chicken, at other times the amount of fat so placed is quite abundant This is the case in pork in highly fattened beef or mutton and in swimming birds such as the duck and goose, which require a large store of fat both to lighten the body and as a source of heat A large amount of fat tends to diminish the digestibility of meat apparently by forming a sort of waterproof coating around the fibres and hindering their solution

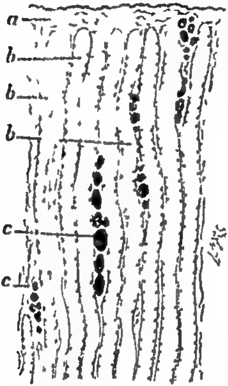

FIG 21 —LONGITUDINAL SECTION OF A PRIMARY MUSCLE BUNDLE
a Connective tissue b muscle fibres c fat cells.

by the gastric juice and it is notorious that pork duck and goose are rather indigestible forms of flesh

The *contents of the microscopic tubes or muscle fibres* consist of water holding in solution proteins salts, and the substances known as "extractives the whole constituting muscle juice The younger the animal the more water does its flesh contain, and the lower is its nutritive value This may be the explanation of the German saying Calf meat is half meat

The chief *proteins* which the juice contains are myosin myogen,

detect, as it were an echo of the aroma of the heather or pine woods amongst which these birds live

The chemical composition of meat varies considerably depending as it does on the particular "cut" examined, on the breed of the animal, and on the degree to which it has been fattened It must be noted also, that by no means the whole of ordinary butcher's meat consists of edible matter, a large part being made up of bone, gristle, tendon, and other inedible portions In an average piece of meat these *waste matters* may be reckoned at 17 per cent of the whole,[1] and the *proportions of the constituents* in the lean edible part are about as follows

Water	75 per cent
Intra-cellular protein	16 1
Extra cellular (collagen etc)	2 4
Fat	*3 0* , ,
Mineral elements	0 7 ,
Extractives	0 8 , ,

Other analyses represent the proportions of the chemical substances present thus

100 PARTS OF LEAN BEEF WITHOUT VISIBLE FAT (BISCHOFF AND VOIT)

Water	75 90
Protein (intra-cellular)	18 36
Gelatin (extra-cellular)	1 64
Fat	0 90
Mineral elements	1 30
Extractives	1 90

The *effects of fattening* are shown in the following table, in which the composition of lean, medium, and very fat beef is stated in round numbers

	Water	Nitrogenous matter [3]	Fat	Mineral elements
Lean	76 5	21	1 5	1
Medium	73	20 5	5 5	1
Very fat	53	17	29	1

The chief points to note in this table are (1) The large amount of water which meat contains About three quarters of its total

[1] *The Nutritive Values of War time Foods* Medical Research Council (1945)

[2] BATE SMITH (1942) *op cit*

[3] Nitrogenous matter is the figure obtained by multiplying the amount of nitrogen in 100 parts by 6 25 i e it is assumed that it is all protein In reality only 85 per cent of the total nitrogen arises from protein and the remaining 15 per cent comes from extractives The factor for converting extractive nitrogen to extractives is 3 12

weight is made up of water or stated otherwise, 1 lb of meat contains ¾ lb water and ¼ lb of nutriment It has been already pointed out that the flesh of young animals is relatively richest in water (2) The relation between water and fat The more there is of the latter present the less there is of the former in other words when fat is deposited in a muscle it replaces water, and not protein and so the gain in nutritive value is an absolute one and is not attained at the expense of a loss of nitrogenous constituents The above analyses refer especially to beef the com

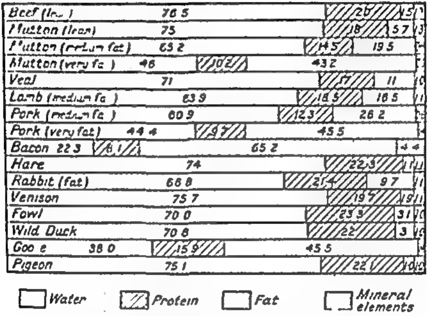

FIG 23—COMPOSITION OF SOME COMMONER VARIETIES OF MEAT AND GAME

position of the other commoner sorts of meat and some varieties of game may be graphically represented as in Fig 23

It must be clearly realized that these results are merely approximate and may vary considerably in different cases Thus in very young calves the amount of water in the flesh may be 80 instead of only 71 per cent The relative proportions of gelatin and other protein also fluctuate considerably The flesh of young animals has more gelatin in proportion to protein than that of older animals hence the value of veal in making soups Red and white meats differ but little in their content of extractives including purines [1]

[1] McCANCE and SHIPP (1933) The Chemistry of Flesh Foods and their losses on Cooking *Med Res Council Special Report Series* No 187

conflict of views in feeding patients. Such idiosyncrasies should be respected when feeding the sick.

The Relative Digestibility of the different kinds of Meat Few exact data are available with regard to this. There is a general impression that ***mutton*** is more easily digested than beef, which some have attributed to the finer fibres and looser connective tissue of the former. ***Veal*** is believed to be somewhat difficult of digestion, though this is denied on the Continent of Europe. The difficulty of digesting veal is somewhat surprising for the connective tissue, though abundant, is very easily changed into gelatin. It is believed by some that the explanation is to be found in the ease with which the fibres of veal elude the teeth on mastication; the rather insipid taste of veal may also be a contributive cause for such foods do not tend to excite a free flow of gastric juice. ***Pork*** too is accounted indigestible though the rate of passage of pork from the stomach does not bear out that suggestion! On the other hand ***bacon*** can often be eaten with impunity by persons to whom pork is intolerable. If we accept the rate of passage of foods through the stomach as a measure of their digestibility we find that lamb among the meats is a little more digestible than beef, and that pork is less digestible than beef. Pork chops fried ham and bacon remain still longer in the stomach. The secretion of acid by the stomach is inversely proportional to the time of passage of the food through the stomach—at any rate with meats [1]

The breast of ***chicken and game*** is amongst the most digestible forms of meat, but the leg muscles are often very tough. Very fat poultry, e g duck and goose should be avoided by the dyspeptic, as the fat of such birds renders the flesh indigestible.

The ***absorption of meat*** is high. It has been shown that only about 5 per cent of the organic matter in meat fails to enter the blood and that as the result of this meat is a food which leaves a very small residue in the intestine. This gives it a special value in some cases of intestinal disease.

Nutritive Value and Economy of Meat

The principal nutritive constituent of meat is protein and it is as a compact and easily digested source of this that meat is chiefly of value. *Meat protein* is characterized by the rapidity with which it can be digested and absorbed into the body, its absorption coefficient is remarkably high, and it has a high biological value. It is moreover, a ' quick fuel ' with a high specific dynamic

[1] Hawk Rehfuss and Bergeim (1926) *Amer Journ Med Sci* 171, 359

action This gives it an advantage in cold weather, but because of these ' heating ' qualities its use should be restricted in summer

It has been held that meat proteins (or possibly the extractives of meat) produce a stimulating effect on the cells and on the body generally, and the feeling of well being which follows a meat meal has been put down to this cause Meat is also supposed to arouse animal passion and to excite savages not accustomed to it to a nervous condition amounting almost to intoxication

All this must surely be exaggerated, for it is not borne out by observations on the diet of native races Whereas the Masai [1] may be warlike on their diet consisting mainly of milk, meat and blood the Eskimos on a diet of meat fish game and eggs are one of the most peaceful of peoples and from all accounts not libidinous

Meat is one of the few articles of diet on which life can be supported alone for an almost indefinite time even by inhabitants of temperate climates It is stated that Stefánsson the Arctic explorer during one of his expeditions lived solely on meat for nine months and that during that time he reached his maximum weight was in excellent health and never suffered from constipation [2]

These observations have been followed up by a series of laboratory experiments in the Russell Sage Institute upon Stefánsson and one of his assistants in Arctic exploration Both lived on a diet of animal protein mainly meat for a year and there was nothing to differentiate them during that year either from other normal people or from their state before and after the experiment except a mild ketonuria [3] which however, was accompanied by none of the usual subjective symptoms There was much less flatulence as judged by X ray photographs than when on a mixed diet and the stools were not offensive

A meat diet entails an extremely high intake of protein less of fat and still less of carbohydrate Stefánsson found, both in his Arctic voyages and in his experimental period of meat diet that fat was essential and lean meat alone not tolerated

There is evidence that most of the ills attributed to a high meat diet—nephritis high blood pressure deposition of urates in the joints lowered alkali reserve increased putrefaction in the colon and constipation—are non existent Man has survived possibly a million years of such diet Moreover there are to day hardy races both in polar and equatorial regions whose diet is mainly meat There is no evidence that the Eskimos suffer more from nephritis hyperpiesia and arthritis than Europeans or Americans

[1] (1931) *Med Res Council Special Report* No 155

[2] CLARENCE LIEB (1926) *Journ Amer Med Assoc* 88 25

[3] MCCLELLAN and DU BOIS (1930) *Journ Biol Chem* 87, 651

It is true that the Masai [1] suffer from arthritis, but a medical officer from Kenya in a private communication gave it as his opinion that it is probably gonococcal in origin and not dietetic We conclude that these supposed ills are unsubstantial bogeys

None the less, meat as a sole source of food is impossible mainly on account of its cost Besides, it would take anything from 3 to 5 lb of meat daily to supply the requisite number of Calories, and meat, as a food, is rather bulky

The relative nutritive value of different sorts of meat depends chiefly on the amount of fat they contain Fat, as we have seen, replaces part of the water, and not the protein of the leaner meats, and thus the fat meats are better sources of fuel than the latter, while not inferior to them in building material Kean's employment of different meats according to the part he had to play that night—pork for tyrants beef for murderers and mutton for lovers —has, as yet, no strictly scientific backing

The Economic Aspect of Meat as a Food From an economic point of view *meat is a dear food* This holds good whether one regards meat merely as a yielder of energy or as a source of building material

The costliness of it however, can be considerably diminished by selecting the cheaper "cuts," which are equal in nutritive value to the dearer kinds, though inferior in tenderness and flavour The question of waste from bone etc must also be considered Thus, in the case of mutton and pork, the leg contains relatively less bone than the shoulder, and in beef there is a much larger proportion of bone in the shin than in the round and of these the least bony parts will be the most economical from a nutritive point of view Much, too can be done to diminish the cost by the use of the cheap *chilled meats* which are now imported These are equal in nutritive value to fresh meat, and are only slightly inferior to the latter in keeping qualities They are not much drier than ordinary meats, as is often stated, for chemical analysis shows that the proportion of water is only 10 per cent less than that of fresh meat, while their digestibility is precisely the same From an economic point of view, also it must be regretted that there exists a prejudice against the use of *horse flesh* as a substitute for ordinary meat It is well flavoured—indeed, a Chateaubriand steak is said by connoisseurs to be best when made of horseflesh—and any toughness can be overcome by suitable cooking

It should be remembered that all small animals such as rabbits are necessarily expensive forms of meat both on account of their active metabolism, which implies that the greater part of the food

[1] ORR and GILKS (1931) *Med Res Council Special Report* No 155

they eat is lost in the form of heat, and also because of the relatively large bulk of their viscera. It is therefore impossible to hope that they can ever be a cheap form of animal food for the poorer classes.

Offal. There remain to be dealt with parts of animals other than the flesh which are sometimes used as food and which are usually classed together under the unsavoury title of offal. These comprise such articles as the kidneys, liver, sweetbreads, blood, heart, lungs and other internal organs, and together they make up about one third of the total weight of the carcase. The importance of some of these in diet cannot be overrated.

The general composition of these articles is shown in the following tables.

PERCENTAGE COMPOSITION OF OFFAL (RAW)

	Water	Nitrogenous matter[1]	Fat	Carbohydrates	Mineral elements
Blood	80.8	18.1	0.2	—	0.85
Brain	80.6	8.8	9.3	—	1.1
Heart (ox)	62.6	16.0	20.4	—	1.0
(sheep)	69.5	17.0	12.6	—	0.9
Kidney (ox)	76.7	16.9	4.8	0.4	1.2
(sheep)	78.7	16.8	3.2	—	1.3
Liver (ox)	71.2	20.7	4.5	1.5	1.6
(sheep)	61.2	23.1	9.0	5.0	1.7
Lung (ox)	79.7	16.1	3.2	—	1.0
(sheep)	75.9	20.2	2.8	—	1.2
Sweetbreads	70.9	16.8	12.1	—	1.6
Tongue (ox) fresh	63.8	17.1	18.1	—	1.0
smoked and salted	35.7	24.3	31.6	—	8.5
Tripe	74.6	16.4	8.5	—	0.5

COMPOSITION OF OFFAL (COOKED) (AFTER MCCANCE AND SHIPP)

	Protein	Fat	Carbohydrates	Calcium	Iron	Phosphorus	Calories per oz
				mg	mg	mg	
Brain calf boiled	12.0	5.8	0	16.0	2.0	35[illegible]	29
Heart sheep roast	25.0	14.7	0	9.5	8.1	389	[illegible]
Kidney ox stewed	25.7	5.8	0	20.8	7.1	392	45
Liver calf fried after rolling in flour	29.[illegible]	14.5	2.4	8.8	21.7	576	74
Sweetbread sheep stewed	22.7	9.1	—	14.3	1.6	596	51
Tongue sheep fresh stewed	18.0	24.0	—	11.1	3.4	186	[illegible]
Tripe dressed stewed	18.0	3.0	—	127.0	1.6	132	29

[1] N × 6.25

It will be observed that, from the chemical point of view, they are substances of considerable nutritive value, and as their price is also for the most part low, as compared with that of ordinary meat, they must be regarded as important sources of protein in the diet Moreover, they have remarkable properties in supplying protective factors in the diet, such as vitamins, iron, etc Liver has massive quantities of vitamin A and the B complex and available iron, the rest are very useful for vitamin B_1

The *liver and kidneys* resemble one another in being compact solid organs, containing but little connective tissue This physical property renders them somewhat difficult of digestion, unless they have either been minced before cooking (as the liver is, for instance, in making a haggis or a faggot), or are rather carefully chewed Chemically, both consist chiefly of protein along with a small amount of fat The proteins which they contain are different from those of ordinary meat for example, there is much nucleo protein, which yields nuclein on digestion Now, nuclein is an important source of uric acid and for that reason gouty persons are recommended to avoid the dietetic use of the articles under consideration

The *heart* resembles ordinary meat very closely as far as chemical composition is concerned but differs from it in being of a denser structure and therefore less digestible For healthy persons, however, it is an excellent and economical food, and might with advantage be made larger use of than it is at present

It seems natural to suppose that *blood* must be a very valuable food The blood is the life' and it would seem as if blood must represent in itself the essence of strength and energy But it is not so and the misconception proceeds from a neglect of the fact that blood is not *in itself* the food of the tissues, but is merely the vehicle by means of which nourishment is carried from the intestines to the places where it is wanted in the body One might as well expect a spoon to be of nutritive value because it conveys food from the plate to the mouth Two French experimenters, Payen and Magendie found that blood when administered to dogs, even in the liberal measure of [illegible] lb daily, did not suffice to maintain the life of the animals for more than a month This is due in part to the fact that blood is a dilute fluid for, of every 100 parts of it, from 78 to 82 consist of water Blood in fact, from a chemical point of view is not so much thicker than water after all In the solids there is plenty of protein, but the other nutritive constituents of food—fat and carbohydrates—are only represented in quite small amount In addition to this, the red colouring matter (hæmoglobin) which makes up the larger part of the protein is a substance which is very

far from being completely absorbed There are, thus no chemical considerations which can outweigh the natural repugnance which most persons feel to the eating of blood and though it may be used without harm if also without much benefit, in the form of black puddings and suchlike there is no reason to advocate its habitual consumption much less its employment in the feeding of the sick and this is true also of the use of blood as a source of iron

The *lungs*, from the fact that the air which they contain enables them to float in water, are popularly spoken of as the "lights" They are sometimes eaten, but cannot be regarded as a really good form of food Their chemical composition furnishes the reason The lungs contain large amounts of elastic material which though protein in nature, is only imperfectly capable of digestion

Under the term *sweetbread* butchers include at least two distinct organs The 'throat sweetbread' is known to anatomists as the thymus gland the 'stomach sweetbread' as the pancreas The thymus of the calf is the one most frequently met with in the market Both glands are cellular organs held together by a loose and delicate connective tissue From the nature of the latter they are easily digested in the stomach and rank amongst the most digestible of animal foods 9 oz of sweetbread being completely disposed of by a healthy stomach in 2¾ hours while a similar weight of beefsteak demands at least 4½ hours for its complete digestion[1] These organs contain much nucleo protein and for that reason, as has already been pointed out in the case of the liver and kidney sweetbreads may prove harmful in some cases of gout

Tripe is the name applied to the stomach and intestines of the ox after being cleaned and boiled It contains a large amount of connective tissue readily changed into gelatin on boiling and so rendering the fibres easily digested It contains fat in small amount but not diffused through the muscular part Its rate of passage through the stomach is slower than that of beef[2] but in the intestine it has been found to be as completely absorbed[3] Unfortunately the absence of extractives causes tripe to be rather deficient in flavour but otherwise it must be regarded as a valuable and easily digested food

The *brain* of animals is only occasionally eaten as food Brain consists largely of a fatty material containing cholesterol and lecithin the latter being comparatively rich in phosphorus In the

[1] PENZOLDT (1893) *Deut Archiv f Klin Med* 51, 535
[2] HAWK *et alii* (1919) *Amer Journ Physiol* 49, 174
[3] SOLOMIN (1896) *Arch f Hygiene* 27, 176

stomach owing to its soft consistency, brain is more rapidly digested than any other animal food but, unfortunately, it is very imperfectly absorbed, 43 per cent of it reappearing in the fæces (*vide infra*) In spite, therefore, of its easy digestion it cannot be regarded as a valuable food for invalids, nor is it in any sense specially apt to "make brains" "Some fancy," says an ancient writer,[1] "that Rabbits' Brains weaken the Memory, because this animal cannot for a moment after retain in mind the Foils laid for her and that she had just escaped, but this conjecture being grounded upon a weak Foundation, I shall not stop here and go about to confute it" The idea that brain can in any way contribute to the nourishment of brain is grounded on an equally 'weak founda tion'

The comparative absorption of some of the articles of which we have been speaking, as found by experiment, is given below

Voit[2] states that

100 parts of dry	liver	yield	5	parts of dry	fæces
"	"	lung	"	8	"	"
"	"	thymus	"	7	"	"
"	"	brain	"	43	"	"

Emil Bergeat[3] found the loss of nitrogen in the dog to be

In meat	2 1 per cent
In thymus	3 2 "
In liver	3 3 "
In lung	4 2 "
In brain	13 9 "

Potted Meats The average composition of some potted meats is represented by the following table (from König)

	Water	Nitrogenous matter	N free Extractives	Fat	Mineral elements	Salt
Foie gras	46 04	14 59	2 67	33 59	3 11	0 22
Potted beef	32 81	17 17	3 36	44 63	2 03	—
ham	20 57	16 88	—	50 88	0 78	5 72
tongue	35 52	18 46	0 46	32 85	6 71	5 9[illegible]

These substances require no special description

[1] LEMERY (1745)
[2] *Zeit f Biologie* (1889) 25, 232
[3] *ibid* (1888), 24, 120

Sausages are preparations of very uncertain composition It has been remarked of them with some truth that they are like life, for you never know what is in them till you have been through them Sausages which are sold to be eaten cold have been cooked those which are meant to be cooked are made of uncooked meat to which bread seasoning and herbs have been added The following analyses by Allen[1] represent the composition of some typical kinds

COMPOSITION OF SAUSAGES

Variety	Water	Fat.	Protein	Gelatin etc	Starch.	Mineral elements
German	46 81	17 87	16 38	1 13	16 00	4 47
Mutton	[illegible]	30 51	1 69	3 11	3 00	2 50
Polony	45 57	32 06	17 26	0 [illegible]	2 30	2 60
Pork	54 09	21 04	12 28	0 67	1 05	3 52
Cambridge	61 54	29 72	9 45	0 72	2 20	3 47

McCance and Widdowson[2] give the following figures for pork sausages

Protein.	Fat	Carbohydrate	Mineral Matter	Energy value per oz.
8 8	28 8	9 8	2 2	[illegible]

Of war time sausages the less said the better, but the Medical Research Council gives the following composition

	Protein	Fat	Carbohydrate	Calcium	Iron	Vitamin B	Calories per oz
				mg	mg	I U	
Sausages beef	11 5	13 0	13 0	30	2 0	50	61
pork	10 5	18 0	13 0	30	1 0	57	73

Analyses of other more recondite sausages and of tinned meats for Army use are given by Atwater and Bryant[3] and by Plimmer[4] respectively

[1] *Commercial Organic Analysis* Second Edition 4, 280

[2] McCANCE and WIDDOWSON (1942) *The Chemical Composition of Foods* H M Stationery Office

[3] ATWATER and BRYANT (1906) *Chemical Composition of American Food Materials* U S Dept of Agriculture Washington

[4] PLIMMER R H A (1921) *Analyses and Energy Value of Foods* H.M Stationery Office

As sources of protein and of Calories, they are certainly not more economical than ordinary meat and their carbohydrate content must be taken into account when feeding a diabetic. They contain more vitamin B_1 than would be expected from the fact that sulphur dioxide is used to preserve them.

The use of bones as food will be dealt with later.

Preserved Meat. As was said earlier in this book, one of the problems presented to man by Nature is to make food keep from a time of glut to a time of scarcity. The industrialization of large numbers of the human race has made that problem still more urgent, and methods have been sought to preserve food produced in plenty in agricultural areas till it reaches man in the town. Particularly is this true of meat, which very rapidly becomes unfit for consumption when exposed to bacterial and other infection. Consequently many different methods have been evolved for making meat keep. Of these the important are salting or pickling with or without smoking, canning, drying and dehydration.

Pickling. This has been practised for many hundreds of years and is applied chiefly to products of the pig. The flesh and blood of animals is practically sterile and a skilled butcher can eviscerate an animal without the flesh becoming contaminated. The sources of infection are the knife with which the pig is stuck, and with the ox the hide. Consequently the knife must be sterile and the skin or hide cleansed before slaughter or sterilized (as in the case of the pig) after killing. The muscle itself has such a hydrogen ion concentration ($P_H = 5.5$) that putrefying organisms cannot grow. So if the exterior can be salted to prevent growth of bacteria, the whole can remain sterile for long periods of time.

Salt mixed with potassium or sodium nitrite is rubbed into the exterior surfaces of the jointed carcase, and penetrating to some distance renders the outside surfaces incapable of supporting bacterial life though moulds do, with careless storage, manage to grow. In commerce the salt mixture in solution is often pumped into the deeper strata. The nitrate, being reduced to nitrite, fixes the colour of the hæmoglobin by converting the hæmoglobin to nitroso hæmoglobin. After pickling the sides are wiped with sterile cloths, and then baled and shipped immediately. Home curing proceeds by salting the joints—ham, gammon and sides—without pumping the pickling mixture into the deeper parts.

Subsequent smoking still further inhibits invasion by microbes and the development of rancidity. Pickled and smoked bacon and ham will keep under ordinary household conditions for at least a year.

Apart from economic considerations—for the pig is the best

converter of agricultural products into first class protein and fat apart from the milch cow—there are dietetic reasons for encouraging the bacon industry. Ham and bacon are more digestible than pork, and retain, in their cured condition, most of the vitamin B_1 which is the hallmark of the flesh of the pig. Whereas ordinary meat contains only some 50 I U of B_1 per 100 grammes, pork and cured pork may contain four to six times as much.

Salting is applied to coarser joints of beef (brisket and silverside) but rather to render them more appetizing than to preserve them. The attempts to cure mutton by salting and smoking practised in the early days of the war of 1939–45, proved a failure.

Analyses of bacon and ham are here given.[1]

	Protein	Fat.	Carbohydrat	Calcium	Iron	Phosphorus.	Calories per oz.
				mg	mg	mg	
Bacon raw Danish Wiltshire	14.0	37.4	0	13.5	1.3	122	115
Bacon raw English Wiltshire	12.5	49.3	0	13.5	0.9	94	144
Bacon back fried	24.6	53.4	0	11.5	2.8	229	169
streaky	24.0	40.0	0	62.3	3.2	238	140
Ham raw	15.0	49.0	0	14.2	1.2	104	146
boiled (lean and fat)	16.3	30.6	0	12.7	2.5	192	123

Canning is a method of preserving meats from decomposition which has reached enormous dimensions in this century. Not only does it make meat available long after the animals were slaughtered (up to 100 years!) but it enables armies, polar expeditions and construction camps of all sorts to be fed with meat protein and fats far from a base of supply of fresh meat, and preserves foodstuffs used in the manufacture of meat extracts which would otherwise be wasted (Corned beef). There is a prejudice against canned meats due to conservatism and gastronomy and there have been in the past accidents of food poisoning traceable to careless processing but with advance of technique these have been largely obviated. There are to-day more cases of food poisoning from fresh meat than from canned meat. It should be emphasized that the canners have discovered by experience that none but the best quality meat canned under conditions of great cleanliness have long life or marketable qualities. Processing consists in submitting meat enclosed in tinned and laquered containers to a temperature of

[1] McCance and Widdowson (1942) *op cit*

125° C long enough for the heat to penetrate thoroughly to the centre of the container and sterilize any adventitious microbic life Though such sterilization destroys the small amounts of vitamin B_1 and C contained in the meat, the proteins and fats are but little affected except that they are cooked Canned meats are then a good and convenient source of protein and energy as the analyses show

	Protein	Fat	Carbo-hydrate	Calcium	Iron	Phosphorus	Vitamin A	Vitamin B	Calories per oz
				mg	mg	mg	I U	I U	
Corned beef	22 3	15 0	0	12 8	9 8	119	—	—	66[1]
"	25 0	16 0	0	10 0	11 0	—	0	0	69[2]
pork	20 0	23 0	0	10 0	2 0	—	0	450	81[2]
Luncheon meat	15 0	21 0	0	—	—	as above	—	—	71[2]
Pork sausage meat	9 0	43 0	1 0	—	—	as above	—	—	121[2]
Tongue	19 0	20 0	0	10 0	3 0	—	0	280	73[2]

Drying has been used from time immemorial by North and South American Indians for preserving meat (pemmican and charque) but it to day finds little use except in polar expeditions If all the water is removed from lean beef the composition of the product would be about as follows

Protein	*86 8 per cent*
Extractives	7 8
Mineral elements	5 4

Beef powders made from dried meat form the basis of the diet of polar explorers Its value is enhanced by the addition of 40 to 50 per cent of fat—the amount varying with the inclinations of the head of the party—and when mixed with boiling water it forms the "Hoosh" familiar to readers of the accounts of exploration Bulk for bulk dried powdered beef mixed with fat is about the most concentrated food known

Dehydration During the war of 1939–45 considerable advance has been made in the drying of meat which has been previously partly cooked and minced The meat with the cooking liquors distributed over it is dried either at 60° C in air or at 70°–80° C under slight vacuum The flavour and nutritive value so far as protein and fat are concerned are fully preserved and the loss of vitamin B_1 is comparable with that of normal home cooked meat Meat so dried when packed in airtight containers with the air replaced

[1] McCance and Widdowson (1942) *op cit*
[2] Medical Research Council (1945)

by an inert gas can be expected to keep in good condition for years [1] This method was used during the war to save transport but what its commercial future will be in years to come is somewhat speculative

Soups, Beef extracts Beef Juices and Beef tea In previous editions of this book considerable space was devoted to these substances but it has been considered unnecessary to repeat what has been said in the past There is but little to be added to the summary given in the 9th Edition

1 The extractives of meat are incapable either of building up tissues or of supplying the body with energy and are therefore not foods

2 They do not act as cardiac stimulants

3 They may possibly help to remove fatigue either by acting on the nervous system or on the muscles directly but this action cannot yet be regarded as proved

4 On the other hand there is no doubt that they powerfully aid digestion by calling out a flow of gastric juice whilst their pleasant flavour enables them to rouse the appetite They are therefore useful additions to other foods especially where the appetite and digestion are feeble and may also be taken with advantage at the beginning of a meal as in the form of soups

5 If taken in large amount they excite diarrhœa

6 Ordinary beef extracts (e g Liebig s) possess no properties other than those of the extractives of meat The amount of protein which they contain is negligible

7 Preparations such as Bovril and Oxo to which meat powder has been added may theoretically be regarded as foods but contain far too little protein to admit of their ever being able to contribute appreciably to nutrition

8 Beef juices differ from beef-extracts in containing the proteins of meat in a coagulable form None of them however can be taken in sufficiently large quantity to supply much protein to the body

9 Natural (home made) raw beef juice contains about 5 per cent of coagulable protein which is as much as many of the patent preparations whilst its comparative poverty in extractives and salts enables it to be consumed in fairly large amounts It is also very much cheaper than the patent preparations

10 Ordinary beef tea even when carefully prepared does not contain more than 2 per cent of nutritive matters It may aid appetite and digestion but is of very little value as a food Its

[1] BATE SMITH SHARP and CRUICKSHANK (1944) *Proc Nut Soc* 1, 118

nutritive qualities, however, can be enhanced by adding to it the finely powdered fibre of the meat ("whole beef tea") It is doubtful if the salts of beef tea are of any real use

We add that the defence of the use of soups must be along the lines that they are a pleasant opening to a large meal, especially in cold weather, they are gastric secretogogues, they may contain the "extrinsic factor" for hæmatopoiesis, and form a good vehicle for vegetables, milk and cheese Whatever growth promoting factor beef tea contains is due to gelatin (q v) The hold which these preparations have on the public is due to a cleverly conducted and intensive advertising campaign

ANALYSIS OF SOUPS[1]

	Protein	Fat	Carbo hydrate	Calcium	Iron	Phos phorus	Calories per oz
				mg	mg	m	
Bone and vegetable broth home made	3 7	4 6	1 1	16 9	0 28	9 9	18
Ditto commercial	4 4	—	0 3	10 2	0 28	7 0	—
Hospital soups (mean of samples)	2 0	1 3	4 3	33 8	1 30	40 0	10

COMPOSITION OF THICK SOUPS (KONIG)

	Nitrogenous matter	Fat	Carbohydrate	Cellulose	Mineral elements	Calories per fluid ounce
Pea soup	3 38	0 93	5 60	0 70	1 13	16
Potato	1 37	1 63	4 87	0 26	0 99	11

COMPOSITION OF EXTRACTS OF MEAT[2]

	Meat Fibrin	Albumoses and Peptones	Gelatin	Non nitrogenous material	Creatine and Creatinine	Mineral elements
No 1	1 3	0 5	0 2	trace	8 5	21 0
No 2	1 9	1 0	0 3		8 1	23 6
No 3	nil	0 7	trace		4 7	20 0
No 4		0 9			4 6	20 7
No 5	5 3	0 4	0 5		5 5	20 3
No 6	6 0	22 4	0 5		6 1	18 2
No 7	8 6	13 3	0 4	10 0	6 3	28 5
No 8	0 6	17 5	8 7	7 0	1 4	15 9

[1] McCANCE and WIDDOWSON *op cit*
[2] COX (1936) *Chem and Ind* 55, 69

Since a level teaspoon holds about 3 5 c c it can be seen how little nutriment is obtained in a cup of meat extract made as the manufacturers direct

COMPOSITION OF COMMERCIAL BEEF JUICES

	Coagulable Protein	Non coagulable Protein	Non nitrogenous Material	Extractives	Mineral Elements	Alcohol
A	0 [illegible]3	9 12	—	11 16	10 84	—
B	[illegible]29	10 17	—	16 [illegible]	8 86	—
C	3 71	9 29	—	8 10	14 20	—
D	8 3		—	9 [illegible]4	7 51	—
E	11 2[illegible]		4 25	—	—	41 35
F	33 39		6 75	13 44	13 27	—
G	21 0		—	6 0	6 [illegible]	—
H	4 40–7 37		53 [illegible]6	0 5[illegible]	1 24	—

As meat is a good source of nicotinic acid and a moderate source of riboflavine it is to be expected that meat extracts should contain great amounts of these vitamins This is so Meat extracts per 100 grammes contain 37 5 to 102 5 milligrammes of nicotinic acid and 2 34 milligrammes riboflavine [1] Doubtless they will be well advertised on that score

Extracts prepared from yeast have for many years been used as substitutes for ordinary meat extracts and are largely used for flavouring the canned stews put up by the canning firms A good example of these is the preparation known as *Marmite* [2]

COMPOSITION OF MARMITE

Water	26 [illegible] per cent
Nitrogenous extractives	34 67
Peptides and amino acids	10 50
Mineral matter	26 95

Such preparations resemble beef extracts so closely in their general characters that they are used to dilute genuine meat extracts [3] The chief chemical difference between beef extract and an extract of yeast appears to consist in the presence of creatine and creatinine in the former, and their absence in the latter yeast extract also contains relatively more of the base adenine [4] Whether these slight

[1] BOOTH and BARTON WRIGHT (1944) *Lancet* 565

[2] Analysis supplied by the makers

[3] For the method of distinguishing yeast extract from genuine meat extract see papers by A SEARL (1903) *Pharmaceutical Journal* 4th series 17 516 704

[4] GAMGEE (1908) *Brit Med Journ*, 2, 449

produce it McCance, Sheldon and Widdowson[1] make a point of the worthlessness of bone and vegetable broth for the purpose for which the bones are included i e to supply calcium for growing children Whereas commercial broth supplies 10 milligrammes calcium per 100 grammes and laboratory made broth 16 9 milligrammes cow's milk supplies 119 and its protein is mainly gelatin against the first class protein of cow's milk

Gelatin is a cheap addition to poor diets in so far as it can be obtained *from many materials which would otherwise be wasted*, and ordinary jellies can only be regarded as dear foods, for say two shillings spent on the "calf's foot jelly" of the shops yields at most 470 Calories and no first class building material at all

[1] McCance Sheldon and Widdowson (1934) *Arch Dis Childh*, 9, 251

CHAPTER XV

FOODS TAKEN FOR MINERAL ELEMENTS AND FOR VITAMINS A AND C

In this chapter it is proposed to deal with fruit and fruit products, leafy and other vegetables and fruits used as vegetables With the usual carelessness of popular dietetics the custom is to lump fruits and vegetables together as the main source of 'minerals and vitamins It is necessary thus early to protest against this and say that calcium and phosphorus are far better obtained from cheese fish and milk than from fruits and vegetables, iron from eggs and liver while butter, eggs fat fish liver and milk contain much vitamin A and liver and nuts are valuable for vitamin C We have already called attention to these points and noted that potatoes, dealt with under energy foods are still unfortunately the main source of vitamin C in the British diet for so many people refuse to eat cabbage The contribution of vitamins of the B class which fruit and vegetables make to the diet is distinctly small As they make but little addition to our sources of energy and protein [1] but are often extraordinarily useful for vitamins A and C they are grouped together in this chapter Fruits often are but by no means always a good source of vitamin C and yellow fruits of vitamin A as well green leafy vegetables produce vitamins A and C and yellow vegetables vitamin A The green vegetables with the exception of the spinach family, have a useful amount of iron and some of the cabbage family make a small con tribution to our intake of calcium

[1] The proteins of leafy vegetables are first class proteins but there is so little obtainable from a consumable amount Methods of con centration of this protein are still in their infancy and may be neglected SLADE BRANSCOMBE and McGOWAN (1945) *Chem and Ind* 117 LUGG and WELLER (1944) *Biochem Journ* 38 408 have found methionine tyrosine and tryptophane well represented in grass and lucerne proteins

urine alkaline [1] As the fruit ripens, these vegetable acids diminish and it is to this fact, coupled with an increase in the amount of sugar present and a decrease or insolubilization of tannic acid that the sweetness of ripe as compared with unripe fruit is due

Fresh fruits, with the exception of grapes plums and some apples, are also important vehicles of the *anti scorbutic vitamin* (See pp 172 and 173)

The ***odour and flavour of fruits*** are due to the presence of very small quantities of ethereal bodies which sometimes elude chemical investigation In many cases, however, we have been able to obtain (from coal tar, too, of all sources) artificial products which have to the uncritical palate the same flavour as many fruits These products, alas, form the basis of the different fruit flavourings and essences sold in the shops Although of no nutritive value the flavouring substances contained in fruits are by no means to be despised as stimulants to the appetite and aids to digestion

Cooking renders most fruits more digestible by softening their cellulose, and it also, as we have seen, converts the gums into a gelatinous form But these changes are not brought about without a good deal of loss The loss affects all the ingredients of the fruit The following instances show figures for the *carbohydrates* [2]

Apples	raw	11 7 per cent	Peaches	raw	9 5 per cent
	once boiled	7 3 ,,		once boiled	1 8
,,	twice	6 1	Pears	once boiled	6 6
Pears	raw	10 1 ,,		twice	5 9 ,,

Where as is usually the case the fruit is cooked by stewing and the juice eaten along with it this effect of cooking is of no moment

*The **digestibility of fruit*** in the stomach and intestine is dependent largely on the nature of the fruit and its degree of ripeness Five and a third ounces of raw ripe apple (one *large* or *two small* apples) require about 3 hours and 10 minutes to pass through the stomach On the other hand if the fruit is unripe and the amount of cellulose consequently greater, digestion may be much more prolonged The excess of acids present in unripe fruit causes *it to be irritating to the intestine* and a frequent originator of diarrhœa and colic *If however* the cellulose and acids are contained in more moderate quantity, *as in ripe fruit*, the gentle stimulation which they exert on the intestinal wall may be very

[1] BLATHERWICK and LONG (1932) *Journ Biol Chem* 53, 103

[2] From analyses by KRAUS (1898) *Zeit f Diat und Physik Therap.*, 1, 69

Composition of Fresh Fruits

	Grammes per 100 grammes.				Mg per 100 grammes.								Acid base, Balance per 100 grammes.	Vitamins. I.U. per 100 grammes.			
	Protein	Available Carbohydrate	Unavailable Carbohydrate	Calories per 100 grammes	Na.	K.	Ca.	Mg	Fe.	Cu	P	Cl.	c.c. $\frac{N}{10}$ Alkali	A	D_1	C	Remarks.
Apples Empire, eating	0·3	12·2	1·7	[illegible]	2·7	116	3·6	5·0	[illegible]	0·14	[illegible]	1·0	30	—	—	20–40	Poor for C.
eating English	0·3	11·7	2·2	49	0	120	3·5	4·3	0·29	0·07	8·5	2·0	[illegible]6	—	40		
cooking English	0·3	9·6	2·4	41	2·1	123	3·6	2·9	[illegible]	0·09	16·3	4·6	[illegible]	—	—	[illegible]0	(Bramley's seedlings.)
Apricots	0·6	6·7	2·1	[illegible]	1·0	320	17·2	1·3	0·37	0·12	1·3	1·0	[illegible]4	2000	—	18	
Bananas	1·1	19·2	3·4	83	1	348	6·8	41·9	0·41	0·16	9·1	4·5	9	250–340	[illegible]	140–[illegible]00	Moderate for C.
Blackberries	1·3	6·4	7·3	[illegible]	3·7	[illegible]03	63·3	[illegible]9·5	0·85	0·12	23·8	22·1	[illegible]4	—	10	—	
Cherries eating	0·6	11·9	1·5	51	2·8	[illegible]8	15·9	9·6	0·39	0·07	16·9	1·0	3	—	—	[illegible]	
Currants black	0·9	6·6	8·7	31	2·7	3[illegible]2	60·3	17·1	1·[illegible]7	0·14	43·3	14·8	80	300	10	[illegible]	The highest source of C, with the exception of hips, haws, and paprika.
Currants red	1·1	4·4	8·2	[illegible]	2·2	275	35·8	1[illegible]8	1·[illegible]	0·12	29·5	16·0	53	—	—	1000	Very good for C.
Damsons	0·5	9·6	4·1	41	2·0	61	21·2	9·9	0·37	0·07	14·6	1·0	74	—	—	—	
Gooseberries green	1·1	3·4	3·[illegible]	16	1·9	10	23·3	7·1	0·3	0·13	33·9	6·3	41	—	—	532	Good for C.
ripe	0·6	9·2	3·5	40	1·2	1[illegible]0	16·5	8·6	0·53	0·15	19·0	10·7	[illegible]	—	—	—	
Grapes (white)	0·6	16·1	0·4	68	1·6	250	19·1	6·6	0·34	0·10	1·0	1·0	60	[illegible]	—	[illegible]	Poor for C.
Grapefruit	0·6	5·3	0·6	4	1·4	[illegible]34	17·1	10·4	0·[illegible]6	0·06	15·6	1·3	64	—	40	520	Good for C.
Greengages	0·6	11·8	2·6	52	1·4	305	16·8	7·7	0·37	0·08	[illegible]2·6	1·0	[illegible]7	—	—	10–135	Poor for C.
Lemon juice	[illegible]	1·6	0·0	8	1·5	14	8·4	6·6	0·14	0·13	10·3	2·6	[illegible]	—	—	5[illegible]0	44 per cent. of a lemon is juice
Loganberries	1·1	3·4	[illegible]	18	2·5	57	35·1	[illegible]5·0	1·27	0·14	24·3	15·8	74	—	—	40[illegible]	Good for C.
Melons (Cant.)	1·0	[illegible]	1·0	[illegible]	13·5	319	19·1	[illegible]0·1	0·81	0·04	30·4	43·5	5	—	10	[illegible]0	Moderate for C.
Orange juice	0·6	9·4	0·0	41	1·7	179	11·5	11·5	0·30	0·05	21·1	1·2	45	300	—	460	57 per cent. of a 8 oz. orange is juice. 41 per cent. of a 6 oz. orange is juice.
Peaches	[illegible]	9·1	1·4	40	2·7	[illegible]59	4·8	7·9	0·39	0·05	18·5	1·0	61	60	—	20–[illegible]0	
Pears eating	0·3	10·8	2·1	43	2·3	1[illegible]9	8·0	9·3	0·19	0·[illegible]0	9·9	1·0	34	80	30	[illegible]0	Poor for C.
Pineapple	0·5	11·6	1·2	50	1·6	247	12·2	16·9	0·4	0·08	7·8	29·5	0	166	2·5	203	Moderate for C.
Plums dessert	[illegible]	9·6	2·1	42	1·7	1[illegible]9	11·0	7·2	0·36	0·10	16·3	1·0	48	115	0	20	Poor for C.
Raspberries	[illegible]	5·6	7·4	[illegible]	[illegible]	[illegible]4	40·7	21·6	1·21	0·21	29·7	[illegible]3	[illegible]	—	25	610	Good for C.
Rhubarb	0·6	1·0	[illegible]	6	2·2	4[illegible]5	102·8	13·6	0·48	0·12	21·0	87·0	—	—	—	—	Ca probably unavailable
Strawberries	0·6	6·2	[illegible]	28	1·5	161	22·0	11·7	0·71	0·13	[illegible]3·0	17·5	33	—	—	920	Very good for C.
Tangerines	0·9	8·0	1·9	[illegible]	2	155	41·5	11·2	0·[illegible]7	0·09	16·7	2·4	53	690	40	[illegible]00	Moderately good for C.
Tomatoes	0·9	[illegible]	1·5	15	2·8	288	13·3	11·0	0·43	0·10	21·3	51·0	[illegible]	14 100	40	259	Frequently higher than this.

useful Hence it is that stewed fruit is so serviceable an addition to the diet for the atonic colon

There have been few experiments made to test the degree to which fruit is absorbed by the human intestine, but one may expect that at least 95 per cent of the available carbohydrate, if not more, will be absorbed, and that is practically all that matters

From a nutritive point of view fruits may be artificially divided into the two groups of ***flavour-fruits*** and ***food fruits*** In the first group are included all fruits which contain less than 20 per cent of solid material, in the second, all fruits or fruit preparations which have more than 20 per cent

The only claim of the members of the first group to be regarded as foods is that they contain a small amount of sugar in a pleasant but rather bulky form and some of them contain vitamin C and most contain vitamin P A rough generalization is that citrus and summer fruits only, with the exception of cherries are significant sources of vitamin C, whereas the autumn fruits, though often almost devoid of vitamin C are useful for vitamin P They are chiefly eaten for the sake of their agreeable flavour Their richness in water makes them more adapted to the requirements of the inhabitants of warm countries than for use in northerly latitudes and it is found if they are freely represented in the diet less water need be consumed

Grapes stand intermediate between the two groups for their juice contains an amount of sugar which varies from 10 per cent in the poorer up to 30 per cent in the richer varieties In the so called ***grape-cure*** from 1 to 8 lb of grapes are taken daily in divided quantities and between meals If the rest of the diet is sufficient the patient may gain weight on this regimen while the grape juice, owing mainly to the organic acids which it contains, acts as a mild laxative and diuretic and at the same time diminishes slightly the acidity of the urine Grapes contain practically no vitamins so far as is known

There are many unfermented grape juices preserved by pasteurization on the market They contain about 25 per cent of grape sugar, and are a useful food beverage, especially in fevers To day in this country there is an 'orange cure,' which consists of combining rest or graduated exercise, fasting from all foods except orange juice with some psychotherapeutic treatment Some of the successes claimed for this treatment we suspect, are due to making good a deficiency of vitamin C

The ***food fruits,*** on the other hand are by no means to be despised as a source of calories Of this group the *banana* is a good example It is the fruit of a tropical plant (*musa sapientum*)

which for some reason or other has forgotten to make seeds but continues to make the pulp in which they should be embedded Bananas are largely grown for export to this country in the West Indies the mainland of Central America, the Canary Islands and the Cameroons

A large banana weighs on the average 143 grammes or 5 oz, and its pulp 90 grammes or 3½ oz The relation of the edible portion to the fruit as purchased is 62 5 per cent Small fruits may weigh as little as 2 oz their pulp not much over 1 oz and the percentage of edible material is 58 5 per cent The size depends on the position the fruit holds in the bunch and on the time at which it is cut Fruit on the American market, because of its proximity to the West Indies is cut later than the fruit destined for the English market It has therefore time to grow larger

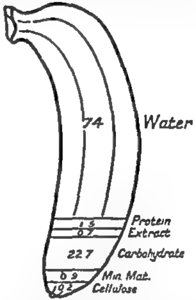

FIG 26 —PERCENTAGE COMPOSITION OF A BANANA.

As will be seen from the tables, the chief value of this fruit in dietetics is its high content of carbohydrate and its considerable amount of vitamin C Figures for the vitamin C of bananas as sold in England are as high as 15 milligrammes ascorbic acid (300 I.U) per 100 grammes[1] Their contents of vitamin B_1 (14 to 30 I U), and of vitamin A (250-340 I U) are not negligible Weight for weight the banana gives at least as many calories as potatoes but whereas the carbohydrate of potato is starch that of the fully ripe banana is sucrose and invert sugars When the banana is green its carbohydrates are mainly starch and if eaten green it should be cooked As the fruit ripens the starch is converted to sucrose fructose and glucose and when fully ripe, i e when the yellow skin is covered with brown flecks there is almost no starch present This is the condition in which the connoisseur eats the banana

Apart from its convenience and cheapness which makes it the fruit of choice for the packet lunch, the meal at mid morning break

[1] CHAPPELL s figures are 11 5–11 9 1940 (*Journ Hygiene* 40 699) L J HARRIS s for ripe Jamaica bananas 11 9–15 2 and OLLIVER s, 6–8 (private communications)

picnic, etc, the banana has achieved a considerable reputation in pediatrics and medical dietetics Enterprising American and Canadian pediatricians *give it as the first solid food a baby* gets and as early as 3 months British pediatricians give it at 6 *months* *The babies take readily to it and thrive on it* *It is* used in the United States to help a child put on weight In this *country, in Germany* and the United States and Canada, the banana is used with success in feeding babies suffering from diarrhœa and cœliac disease[1] It must be very ripe when used for this purpose During the war of 1939–45 the Ministry of Food allowed the importation of amounts of dried bananas to be used in treating infants with diarrhœa It is also an excellent food in the diet for sprue and for a spastic colon in the adult

The unripe banana is dried and used to produce ***banana meal*** or ***flour*** A sample of such a flour had the following composition

COMPARISON OF BANANA AND WHEAT FLOUR

	Banana Flour	Wheat Flour
Moisture	*13 0 per cent*	13 8 per cent
Protein	4 0 ,,	7 9 ,,
Fat	*0 5* ,,	1 4 ,,
Carbohydrates	80 0 ,,	76 4
Mineral elements	*2 5* ,,	0 5 ,,

We have placed alongside it the composition of a good wheat flour compared with which the banana meal is rich in carbohydrates and mineral elements but poor in protein If rice had been used for comparison, banana meal would be about equal to it

An advantage of the banana is the cheapness with which it can be produced A given area devoted to its cultivation will yield a larger food return than if planted with potatoes The bread fruit the sugar cane and the chestnut are said, however, to exceed the banana in their yield per acre

Dried Fruits Surpassing even the banana in nutritive value are the dried fruits, e g *the currant date, fig* raisin and sultana The date *is as much a staple* article of diet to the Arab as rice is to the Hindu but the *carbohydrate of the date is almost* solely sugar whereas that of rice is starch Dried fruits have *received much advertisement in the United States for their content of iron* though the tables hardly bear this out, but we call attention to the large amounts of calcium *and iron in dried figs* Dried fruits unlike fresh fruits have a high Calorie value ranging from 50 per ounce (dried apricots) to 69 *(dates)* Advantage of this is taken by school caterers rock climbers and 'hikers' They must not be relied

[1] PARSONS (1932) *Am J Dis Child* 43 1293

COMPOSITION OF DRIED FRUITS[1]

	Grammes per 100 grammes		Calories per lb	Milligrammes per 100 grammes.								Vitamins. I.U per 100 grammes.		
	Protein.	Available Carbo hydrate		Na	K.	Ca.	Mg	Fe	Cu.	F	Cl	A.	D	C.
Currants	1.7	63.1	1346	19.5	708	95.2	36.2	1.82	0.48	40.4	15.7	—	—	Probably nil
Dates	2.0	63.9	1369	4.8	754	67.9	58.5	1.61	0.21	63.8	290.0	600	30	"
Figs	3.6	52.9	1174	86.7	1015	284.0	92.3	4.17	0.24	91.5	166.0	—	9	
Prunes	2.4	40.3	871	12.2	864	37.7	26.7	2.90	0.16	83.0	2.5	—	66	
Raisins	1.1	64.4	1362	52.2	860	60.6	41.7	1.55	0.24	32.8	8.5	—	50	"
Sultanas	1.7	64.7	1379	52.7	856	52.2	35.3	1.82	0.35	91.5	16.5	—	60	"

[1] *Analyses from* McCANCE WIDDOWSON and SHACKLETON (1936) *Med Res Council Rep* No 213 and vitamins from ROSCOE and FIXSEN (1937–8) *Nut Abs and Rev* 7 823

Food	100 grammes contain							Calories per oz
	Protein	Fat	Carbo-hydrate	Cal cium	Iron	Vitamin A as Carotene	Vitamin C	
	g	g	g	mg	mg	I U	mg	
Brussels sprouts	4 4	0	4 0	27	1 2	400	100	7
Cabbage	1 5	0	6 0	65	1 0	900	70	[illegible]
Cauliflower	2 4	0	3 0	23 [1]	0 9	0	70	4
Kale	3 9	0	4 5	200	2 5	4 000	130	7
Turnip tops	2 5	0	3 5	[98]	[3 0]	10 000	100	5
Watercress	2 9	0	0 6	222	1 6	5 000	60	3

Olliver [2] considers that 100 grammes cooked cabbage contain but 16 milligrammes vitamin C whereas when raw, the figure was 70 Sprouts show a decrease from 100 milligrammes (raw) to 30 milli grammes cooked, and these are probably optimal figures

The Spinach Family These (summer spinach winter spinach seakale beet) are like the cabbage tribe in being sources of vitamins A and C, but are probably useless for calcium and iron because of the oxalates they contain Again there is loss of vitamin C on cooking (65 milligrammes falls to 25 per 100 grammes), but probably none of vitamin A precursors As with the cabbages their Calorie value is negligible (4 per oz)

Leguminous Green Vegetables These are broad French and runner beans and green peas Sometimes these are eaten pods and all (French and runner beans, sugar peas and young broad beans) and sometimes the seeds are shelled and eaten alone (flage olets, peas) Not only are such vegetables quite useful for vitamins A and C, but they afford more protein when eaten shelled than ordinary green vegetables The following analyses illustrate these points

Food	100 grammes contain							Calories per oz
	Protein	Fat	Carbo-hydrate	Cal cium	Iron	Vitamin A as Carotene	Vitamin C	
	g	g	g	mg	mg		mg	
Beans Broad	7 2	0 5	9 5	30	1 1	—	30	27
French	1 1	0	2 6	33	0 7	600	10	4
Runner	1 1	Trace	2 9	33	0 7	600	20	5
Peas green	5 8	0	9 5	15	1 9	500	30	18

[1] Cauliflower boiled (McCance and Widdowson *op cit*)
[2] Olliver (1943) *Chem and Ind* 62, 146

Leafy Salad Vegetables Endive and lettuce are useful practically only for vitamin A, they contain disappointing amounts of vitamin C though judging by American figures there are varieties of lettuce with high vitamin C values

Food	100 grammes contain							Calories per oz.
	Protein	Fat.	Carbohydrate	Calcium.	Iron	Vitamin A as Carotene	Vitamin C	
				mg	mg		mg	
Endive	1 8	0	0 9	44	2 8	—	20	2
Lettuce	1 1	0	1 6	26	0·7	4 000	16 [1]	3

Celery chicory and dandelion, though green leafy vegetables, are eaten blanched They are probably useless for vitamin A, and the vitamin C of celery is low (5 milligrammes per 100 grammes) and their value is mainly gastronomic

Asparagus and Globe Artichokes These luxury articles are not of much importance in dietetics except that asparagus contains much vitamin C 60 milligrammes per 100 grammes (cooked 30 milligrammes) They both are vehicles for melted butter

Food	100 grammes contain							Calories per oz
	Protein	Fat.	Carbohydrate	Calcium	Iron.	Vitamin A as Carotene	Vitamin C	
	g	g	g	mg	mg	I U	mg	
Artichokes (Jerusalem)	1 6	Trace	3 2	30	0 4	?	?	5
Asparagus	2 0	0	2 4	28	0 9	700	60	5
Beetroot	1 8	0	8 1	32	0 9	0	10	7 [2]
cooked	1 8	0	9 9	30	0 7	0	15	13 [2]
Carrots	0 7	0	4 9	48	0 6	10 to 20 000	10	6
Leeks	2 5	0	3 9	61	1 3	700	20	4
Onions	0 9	0	4 7	31	0 3	0	10	6
spring	0 9	0	7 7	135	6 2	700	20	8
Parsnips	1 7	0	10 2	55	0 6	200	10	9
Radishes	1 0	0	2 5	44	1 9	0	30	2
Salsify (boiled)	1 9	Trace	2 8	60	1 23	?	?	5
Swede	0 7	0	2 4	40	0 3	0	20	4
Turnip	0 5	0	1 8	55	0 3	0	15	2

[1] Other values are 16 (OLLIVER *op cit*) and 1–17 (CHAPPELL *op cit*)
[2] Difference due to sampling

Zanzibar, Madagascar India and the West Indies In cloves there is no less than 6 per cent fixed oil and 19 per cent volatile oil and the chief ingredient of the latter is eugenol (cp Allspice or pimento) which is the main flavouring agent

Ginger is the rhizome of a reed like plant, needing moisture and a tropical climate, grown in India, Siam and China and also in East Africa and Jamaica In China the green rhizome is preserved in syrup or candied and exported to all parts of the world It is also dried, bleached and exported as root ginger It contains about 4 per cent fixed oil and 2 per cent volatile oil The fixed oils contain pungent principles mainly zingerone, to which ginger owes its sharp taste The volatile oils to which ginger owes its fragrance are mainly terpenes

Mustard is a flour made from the seeds of black mustard (*brassica nigra*) mixed with that from white mustard (*brassica alba*) On moistening, the black mustard flour contributes volatile mustard oil and the white an excess of a ferment, myrosin which sets free allyl isothiocyanate from the volatile oil to which the burning sensation produced by mustard is due The substance upon which the ferment acts is potassium myronate a glucoside which also occurs in horse radish roots and in turnips It has a bitter taste but no decided odour until hydrolysed by the ferment

Mustard flour contains from 15 to 25 per cent of fixed oil 0 5 to 2 per cent volatile oil, 35 to 45 per cent of nitrogenous matter, 1 6 to 4 9 per cent of carbohydrate and cellulose and 4 to 6 per cent of mineral elements

Nutmeg is the kernel of the small pear like fruit of *Myristica fragrans* from the East Indies (Penang, Singapore etc) but it is also cultivated in the West Indies It has about 25 per cent of fixed oils and 2 5 to 5 per cent of volatile oils These latter contain mainly terpenes (pinene and camphene) and are the main odorous substances

Pepper is the berry of a woody vine growing wild on the Malabar coast in India It is also cultivated in Java, Sumatra the Philippines and the West Indies The chief centre of export is Penang Black pepper is the berry picked before ripening and dried in the sun or over fires White pepper is the fruit picked ripe from [illegible] the outer coat has been rubbed off Black pepper is mor[illegible] than white and whereas white is the more popular in E[illegible] s the pepper of choice in North America The conn[illegible] s black pepper freshly ground to commercial [illegible] o[illegible] pungency to an alkaloid piperine [illegible] whe[illegible] first tasteless Only on reaction

with colloid substances on the tongue or elsewhere does it develop its characteristic pungency

Saffron is the dried stigma of a crocus (*crocus sativus*) from the Middle East As a spice or a colouring matter it is little used in this country except in Cornwall It probably owes what flavour it has to a terpene and a tertiary alcohol

Salt and sugar have already been considered in other places Both are very important condiments in common use in fact the most important condiments It is almost accidental that they have important functions in metabolism The condiment value of sugar is demonstrated by the way in which diabetics as well as the general populace during the war of 1939–45 have recourse to saccharin (benzoic sulphamide) and dulcin (para-ethoxyphenylurea) These are non metabolizable substances very much sweeter than sugar

Vinegar is or should be the result of the oxidizing action of a group of microbes—*Acetobacter aceti A Pasteurianum A Kutzingianum* and others [1]—on wine or malt liquor On the Continent wines are used for the manufacture of vinegar but in this country malt liquor is usually the source Sometimes the vinegar is distilled and the distillate contains acetic acid mainly along with traces of alcohols and esters This vinegar is practically colourless

The substance which gives vinegar its "bite" is acetic acid while it is the substances present in the alcoholic liquor which give it its aroma

In addition to these 'natural' vinegars there are on the market 'artificial' and 'spirit' vinegars The former is made by diluting acetic acid obtained from the destructive distillation of wood or otherwise and adding colouring matter to match the colour of brewed vinegar Spirit vinegar [2] is made from cane molasses which is diluted and fermented The resulting alcohol is distilled off, mixed with ordinary vinegar and water and a 'bacterial nutriment' and passed to 'acetifiers' Here a secondary fermentation takes place and as the fluid comes from the acetifiers it contains as much as 12 to 13 per cent of acetic acid It is sold under the name of spirit vinegar As it contains more than twice as much acetic acid as vinegar it is more pungent and pleasing to the debauched palate

Vinegar is a condiment much used by urban populaces It is said to soften the fibres of hard meat and salads but it can have little use in diet other than stimulating appetite In small amounts

[1] GALLOWAY and BURGESS (1941) *Applied Mycology and Bacteriology*

[2] *Analyst* (1938) 63, 410

and the nature of the diet If external temperature is high or exercise is great, much more water is excreted via the skin and the lungs and if the water drunk is not increased, either the volume excreted in the urine will be decreased or the tissues dehydrated, or both The importance of increasing fluid intake in such circumstances is obvious and fortunately it is usually automatically regulated by thirst The loss in the fæces depends on the nature of the diet If vegetarian, much more is lost by that path than if the diet is predominantly animal in origin

Dehydration of the body occurs if not enough water is drunk, if there is persistent vomiting or diarrhœa or if there is a loss of electrolytes from the body as in vomiting due to pyloric stenosis (loss of chlorides) or as in Addison's disease (loss of sodium ions) The effects of dehydration are as follows (i) thirst (ii) loss of weight, (iii) disturbance of the acid base equilibrium, (iv) rise in the non protein nitrogen of the blood, (v) wrinkling of the skin, recession of the eyeball, etc, and (vi) rise of temperature

On the other hand excess of water *in the tissues* will produce a fall of temperature, vomiting, convulsions, coma, and death This state of water intoxication is rarely likely to be seen in man except possibly in the treatment of diabetes insipidus with pituitrin when water consumption has not been decreased It can easily be produced in animals by giving water by intubation and interfering with kidney excretion by injecting pituitrin

The above facts have been cited to show that, while there is a distinct danger in drinking too little water there is little or none in drinking much We have stated above that the minimum daily intake with a normal diet, temperature surroundings and a sedentary existence is 1000 c c or 1¾ pints Much more can be taken without the slightest danger So exact is the regulatory mechanism of the body that two or three litres of water, taken on an empty stomach will be excreted by the kidneys in the course of the next two or three hours without the concentration of the blood being significantly altered The kidneys in such a case excrete practically distilled water

Such water must pass from the bloodstream into the tissues to be stored there till excretion takes place It is interesting to note that, according to Adolph, water taken on an empty stomach and passing as it does to the tissues provokes a diuresis of greater volume than the fluid drunk This may explain the observation, made by people taking strenuous exercise, that drinking water on an empty stomach leads to still greater thirst Water taken with a meal is by no means rapidly excreted a fact which should be utilized by cyclists, hikers, and enuretics Diuretic drinks such

as tea, coffee alcohol, and to a less extent cocoa, may also increase thirst instead of assuaging it, if taken on an empty stomach

We may sum up the practical results of the above considerations as follows

(i) The minimum intake of water should be about 1⅞ pints per day

(ii) This can be greatly exceeded with advantage in evoking interchange between intracellular and extracellular fluid without danger either to the normal person or the sick

(iii) Water taken on an empty stomach may even increase thirst

(iv) Except when taken in these circumstances water is naturally the best thirst quencher, but if the stomach is empty milk is certainly better

As we have indicated earlier, excessive perspiration in hot surroundings or as the result of exercise may deplete the body of sodium and in such cases the fluid taken to replace the water lost should contain salt

Influence of Water on Digestion The first point which it is necessary to emphasize in this connection is that *water is not absorbed by the mucous membrane of the stomach* This is certainly a surprising fact, but it has been incontestably established both by physiological experiment and by observations on patients suffering from obstruction at the outlet of the stomach

When water enters the stomach, it begins to flow out into the intestine almost at once Roughly speaking one may assume that a pint of water will have entirely passed from the stomach in the space of about three quarters of an hour [1] The precise rate of leaving however, is very markedly influenced by temperature Hot water escapes from the stomach much more rapidly than cold.[2] The heat increases powerfully the movements of the stomach walls and at the same time seems to cause the pylorus to open so favouring the escape of the contents The stimulating effects which hot water exerts on gastric peristalsis render it a powerful aid to sluggish digestion, while the unlocking of the pylorus which it brings about is probably the explanation of the almost instantaneous relief which it affords in many cases of stomach pain

The fact that water is exclusively absorbed in the intestine has important bearings on the treatment of patients suffering from dilated stomach In the extreme form of that disease when the stomach contents are quite unable to escape through the pylorus,

[1] MORITZ (1894) *Munch Med Wochensch* 41, 816

[2] SCHÜLE (1895) *Zeit f Klin Med* 28 461 (1896) *ibid* 29, 49

the entrance of water into the blood is arrested, and the patient is the victim of a "tissue thirst," to which much of the emaciation and discomfort from which he suffers must be attributed Not only is this so The deficiency in the supply of water to the blood may go so far that the proper excretion of waste products is interfered with, and toxic symptoms, such as coma or convulsions, may then supervene In such cases there is an imperious necessity for getting water into the blood *per rectum* or intravenously

The rapidity with which water passes through the stomach causes it to be a very dangerous vehicle of infection, for the hydrochloric acid of the gastric juice has no time to act upon any germs which it may contain For this reason contaminated water is a more obnoxious carrier of disease than impure milk

It is commonly said that the free consumption of water at meals is apt to delay digestion by diluting the gastric juice This statement is not well grounded Water is itself a slight, though unimportant, excitant of gastric secretion, and experiment has shown[1] that even in quantities of ½ litre (about a pint) it does not in any way affect the rapidity of digestion Even 1 litre produces only slight slowing, while it requires quantities of 1½ litres (about 3 pints) to produce any marked effect

On the other hand, it must be remembered that water may actually hasten the digestion of some foods by softening them and favouring their reduction to a state of pulp while hot water is, as we have seen a powerful stimulant of the stomach movements

While foods may readily enter the blood when taken without water none the less drinking at meals facilitates the process of absorption (Adolph)

Influence of Water on Metabolism The influence of water on the chemical processes of the body would seem to be very slight It was formerly believed that an increased consumption of water was accompanied by an increased waste of the nitrogenous tissues This is now regarded as an error Any increased excretion of nitrogen which a free consumption of water entails is ascribed, not to an increased breaking down of the body substance, but to a washing out of the tissues and the elimination of waste matters loitering in them[2] This eliminative function of water is one of the first importance It indicates the necessity for a free supply of that fluid in such diseases as gout, diabetes and fevers, and in cases in which the excretory power of the kidney has deteriorated

[1] MILLER BERGHEIM REHFUSS and HAWK. (1920) *Amer Journ of Physiol* 52, 28

[2] See NEUMANN (1899) *Archiv f Hygiene* 36, 248 BERGHEIM and HAWK (1931) *Physiological Chemistry* 601

Varieties of Water A good drinking water should have little or no colour, no odour, a pleasant, fresh taste, and should contain only a moderate amount of solid matter 8½ grains per gallon being a good average A tumblerful of ordinary London water contains only about one grain of solids A wholesome water should contain very little organic matter and that should be of vegetable origin and if it has anything like a large proportion of chlorides it should be viewed with suspicion

The amount of calcium salts which drinking water contains is a matter of some importance and the relative merits of hard and soft water for drinking purposes have been much discussed It has been maintained on the one hand that hard waters are apt to be productive, in those who habitually consume them of such diseases as goitre and stone while on the other hand it has been said that soft waters may favour the development of rickets It must be admitted that neither of these contentions is very well founded but it may be granted that it is well that the water one drinks should not contain more than 17 grains of calcium salts in every gallon, and that the sulphate of calcium is more likely to be harmful than the carbonate for in some susceptible persons its presence may excite dyspepsia and diarrhœa [1]

The fear that the use of soft water may lead to the development of rickets is quite groundless When one remembers that even a hard water only contains about 0 002 grammes of calcium in every 100 c c and that an infant requires about 0 32 grammes daily it will be evident that, as a source of calcium for the bones water may be practically disregarded On the other hand there is no doubt that soft waters are more liable to become contaminated with lead than those which are richer in lime salts and in that respect at least soft water may be a source of danger to health

Mineral Waters

From time immemorial the sight of water gushing from the rock has appeared miraculous and numinous [2] and should the water be hot as at Bath impregnated with carbon dioxide as at Matlock or have a strong odour or taste as at Bath and Tunbridge Wells medicinal powers are attributed to them At one time and another it has been and possibly again will be fashionable to 'drink the waters at various 'spas, up and down the country There was

[1] This is confirmed by the experience of three members of the family of one of us (V H M) living during the war of 1939–45 in a part of Leicestershire where the content of calcium sulphate in the water is the highest we have met

[2] The Roman name for Bath was Aquæ Solis

once one in Bermondsey London, S E, and at Sadlers Wells, W C 1 For those who could not go to "drink the waters" they have been bottled and distributed through Europe, and thus has grown up a considerable trade in "mineral waters" To day, though we may discount their health giving powers, they are a useful mild stimulant to the flow of gastric juice or may be used to neutralize "acidity," or as a substitute for local drinking water which may be under suspicion or unpleasant to drink because too highly chlorinated

Natural Mineral Waters How far the majority of the mineral waters listed in previous editions of this book will be obtainable in the years after the war of 1939–45 is unknown as yet The lists given there are here repeated in modified condensed form

NATURAL MINERAL WATERS

Adonis A mildly alkaline water containing 2 3 grammes sodium bicarbonate per litre soft well aerated from springs in the Belgian Ardennes

Appolinaris An alkaline highly aerated and slightly chlorinated water containing sodium chloride and carbonates of sodium calcium and magnesium from a spring in the valley of the Ahr (Rhenish Prussia)

Arkina A mildly alkaline Swiss natural sparkling water containing bicarbonate of magnesium

Contrexéville A slightly gaseous water containing 1 3 grammes of earthy carbonates per litre

Johannis A mildly alkaline well aerated water containing sodium chloride and carbonates of calcium and sodium from the Johannis springs at Zollhaus Nassau

Perrier A mildly alkaline well aerated natural water containing bicarbonate of soda mainly from Les Bouillens Vergèze in France

Ramlösa A mildly alkaline aerated water containing no calcium or iron from a spring in Sweden.

Rosbach A mildly alkaline well aerated water containing bicarbonates of calcium and sodium and a small amount of sodium chloride from a spring near Homburg

St Galmier A water containing 2 8 grammes solids per litre mainly earthy bicarbonates

Seltzer A water containing 3 6 grammes solids per litre including 2 24 grammes sodium chloride and 1 3 grammes of carbonates from Nieder Selters in Nassau

Sinaro A natural sparkling water, containing bicarbonates of calcium and sodium from Wiesbaden, Nassau

Vichy A water of high alkalinity with 8 grammes solid matter per litre including 5 grammes of sodium bicarbonate

The acid neutralizing power of one litre of five of these waters expressed as decinormal sodium hydroxide is as follows Apollinaris, 307 2 c c , Johannis 127 2 c.c , Perrier, 60 0 c c Rostach, 117 2 c c , Vichy, 553 c c

The dietetic advantages of the use of natural mineral waters may be presumed to be as follows They have a pleasant sharp taste due to the carbon dioxide with which they are impregnated and there is evidence that that gas stimulates an early and abundant flow of gastric juice [1] It also is said to stimulate gastric movement, while the bubbling of the gas through the stomach contents facilitates their disintegration.

The slight alkalinity of some of them renders them useful additions to the more acid wines and also in cases of hyperchlorhydia

On the other hand when the stomach is dilated, when there is a tendency to flatulence or when the heart is functioning abnormally they should be avoided

Unfortunately it cannot always be claimed for the mineral waters that they are always sterile, though their makers are extremely careful in preparing them treating the bottles into which they are put with greater antiseptic care than is necessary, say for beer Generally speaking recognized brands may be trusted to contain no pathogenic organisms

Artificial Mineral Waters The method of impregnating ordinary water with carbon-dioxide was discovered by Priestley in the latter half of the eighteenth century Mineral waters can be made by charging water with the gas which to day is an article of commerce either liquid or solid under high pressure Ordinary bottles of aerated water contain 3 or 4 volumes of gas to one of water , syphons contain more When the pressure is released the carbon dioxide comes out of solution but not all at once In doing so it withdraws heat from the water, so that aerated waters are always cooler to the tongue than ordinary water kept under the same conditions

The varieties of artificial aerated waters which call for mention are as follows

1 *Ordinary Water impregnated with Carbonic Acid Gas* The best makers obtain the water from springs or artesian wells so that it is of great purity Ordinary water so impregnated is

[1] PENZOLDT (1902) *Deut Arch f Klin Med* 73, 200

often, but erroneously, described as "soda water" As soda is sometimes entirely absent, it is better to describe it simply as 'carbonated water'

Aerated Distilled Water In this case the water is distilled prior to being charged with gas It is therefore entirely free from mineral matter and from all impurities Examples of such water are sold under the names of 'Puralis,' "Salutaris,' and "Globenaris'

3 *Water to which Various Chemical Salts have been added*, e g

Soda water, containing 3 to 5 grains of sodium bicarbonate to the bottle

Medicinal soda water containing 15 grains of sodium bicarbonate ditto

Potash water, containing 15 grains of potassium bicarbonate ditto

Magnesia water containing 12 grains of magnesium carbonate ditto

Carrara water containing 5 grains of calcium carbonate ditto

Lithia water containing 3 to 5 grains of lithium carbonate ditto

4 *Imitations of Various Natural Mineral Waters* One of the best examples of these is seltzer water which is intended to be a substitute for the natural water obtained from the Selters spring Its ingredients are common salt sodium bicarbonate, magnesium carbonate, and hydrochloric acid By the interaction of these constituents an aerated water is produced which "gives a good imitation of the peculiar mellowness of genuine seltzer' An analysis of Schweppe s seltzer shows it to contain 24 grains of inorganic salts per imperial pint or 12 grains per bottle A tumblerful (5 oz) has an acid neutralizing power equal to that of 25 c c of decinormal soda or 100 per litre

The question of *natural versus artificial mineral waters* must be decided entirely in favour of the former For one thing the natural waters do not contain any excess of gas and a larger proportion of what they do contain is present in a combined form than is the case with the artificial waters Hence their gas is given off more slowly and they remain longer brisk and are less apt to lead to sudden distension of the stomach The following experiment bears this out [1]

[1] *Analytical Reports* (1891) *Lancet*

	Natural Water	Artificial Water	
Gas evolved	480 c c	760 c c	Bottle opened and exposed for half an hour
Gas remaining	1010 c c	723 c c	
Total	1490 c c	1483 c c	

There is also reason to believe that the effects of the salts in natural mineral waters are such as cannot be obtained from any artificial imitation of them Zwaardemaker attributes important physiological actions to the radioactive elements and these are sometimes found in the natural waters

Soft Drinks There is a large and popular group of beverages which includes lemonade ginger beer *et hoc genus omne* Mostly they consist of water sweetened with cane sugar rendered tart by the addition of an acid flavoured in any way desired and finally charged with carbon dioxide They are sometimes synthetic but the trend in the best firms is to use flavourings extracted from root ginger and fresh fruits and a proportion of fruit juice in specific fruit drinks We give a recipe for making the basis of one of the more aristocratic of these drinks

GINGER ALE

Syrup (10 lb sugar to 100 oz of water)	1 gallon
Compound tincture of ginger (or tincture of capsicum 1 oz)	4 oz
Citric or tartaric acid	4 oz
Colouring	½ oz

1 to 1½ oz of this mixture are added to a bottle which is then filled with water and aerated

Genuine fermented ginger beer (stone ginger) is a very different product A wort made from water sugar bruised ginger tartaric acid and oil of lemon is fermented by yeast as in the case of beer It often contains 2 per cent of alcohol and sometimes more

Most of these drinks synthetic or otherwise are probably harmless except to the palate The same observations as made above concerning mineral waters apply to them when treating dyspepsia and heart troubles Moreover it must not be forgotten that they contain about 30 grammes sugar to the bottle and this must be taken into reckoning with diabetics

Fruit Juices In the United States the production of fresh fruit juices has risen to enormous dimensions within the past decade The juices are expressed from the fruits by special machinery adapted to each fruit clarified or not according to whether the flavour is carried mainly in the pulp particles bottled and pas

teurized This preserves the fruit flavour and a large proportion of the vitamin C in the original fruit, and, of course, the sugar These juices are extremely pleasant to drink and have great value in the sick room On the commercial side they are of value in making use of gluts of fruit and preserving the value of the fruit till another time American soldiers in this country during the war of 1939–45 have much missed the soft drinks and fruit juices of their own country

A small beginning has been made in this country in the supply of apple juice and blackcurrant syrup though the price of the apple juice is 30 *per cent higher than that of the same quantity* of bottled cider From the dietitian s point of view this is unfortunate The Medical Research Council's analyses of these fruit products is here given

	100 grammes contain							Calories per oz.
	Protein	Fat.	Carbo-hydrate	Cal cium.	Iron	Vitamin A	Vitamin C	
	g	g	g	mg	mg		mg	
Blackcurrant syrup	0	0	46 0	20	2 0	—	55	52
Orange juice	0	0	50·0	—	—	—	160	57
Rose hip syrup	0 6	0	50 0	—	—	—	150	59

It will be seen from these figures that fruit juices are quite useful for Calories and excellent for vitamin C Apple juice will, of course, have much less vitamin C and its main use is that of giving pleasure, along with a small amount of Calories though claims have been made that it is useful in treating intractable diarrhœa Its sugar content (expressed as invert sugar) is 8 5 per cent and its acidity (expressed as malic acid) is 0 5 per cent [1]

Tea, Coffee and Cocoa In four widely separated parts of the world man has discovered plants whose leaves or seeds on extraction with water, yield stimulating drinks containing drugs of the methyl purine group These drinks are *tea*, *coffee*, *cocoa* and *maté* Except for the last mentioned, these drinks have attained a world wide popularity

TEA [2]

History The earliest credible mention of tea was made in A.D 350 and the first handbook on the subject in A D 780, both of

[1] Private communication from Miss Olliver

[2] The standard work on tea is *All about Tea* by W H. Ukers The Tea and Coffee Trade Journal (1935)

course in Chinese Tea was introduced into Europe by the Dutch East India Company in the year 1610 As its price was at first ten guineas a pound, it can be readily imagined that it grew but slowly in popularity, and even in 1660 we find Pepys writing in his *Diary* "I sent for a cup of tee, a China drink, *of which I had never drank before*"

Up to the year 1862 nearly all our tea was obtained from China, the imports from that country reaching their maximum in 1879 Since that time the consumption of China teas has rapidly declined, their place being taken by Indian tea and, since 1880 by teas grown in Ceylon

Mode of Manufacture The tea plant grows wild in Assam and attains a height of thirty feet, but it has been cultivated for centuries in China The cultivated plant was called *Thea sinensis* by Linnaeus, who afterwards altered its name to camellia Modern botanists however, refer to both the wild and the cultivated plant as *Thea sinensis* and the camellia as *Thea Japonica*

The plant "flushes" or sends out young shoots throughout the year in South India Ceylon, Java and Sumatra but in North India, China, Japan and Formosa the "flushes" occur roughly from spring to autumn only A tropical climate is not essential for the cultivation of the tea plant [1]

The young shoot has two small leaves at its tip which contain least fibre and most juice and therefore produce the finest sort of tea, but coarser pluckings including three or even four leaves are not rare (see Fig 27) The terms Flowery Orange Pekoe Orange Pekoe and Pekoe now refer to the various grades of siftings Flowery Orange Pekoe has many tips in evidence, the next finest is Orange Pekoe and after that Pekoe The terms Pekoe Souchong and Souchong are used for teas containing coarser leaves

The treatment of the leaves after they are picked varies according as black or green tea is to be produced

For the production of ***black tea*** the leaves are "withered" then rolled till they become soft and "mashy," (the object of this being to break up the fibre and cells of the leaf, and liberate the juices and enzymes) and then allowed to ferment During the process of fermentation, some of the tannin in the leaves appears to be oxidized and converted into red brown, and insoluble quinones [2] while an essential oil seems to be produced and a slight bitterness developed After fermentation is complete the leaves are "fired" in a drying machine

[1] DANIEL HALL *Our Daily Bread*

[2] These substances are usually termed tannin but unlike the tannin of oak etc they will not "tan" leather

For the production of *green tea,* the fresh leaves are withered in hot pans at a temperature of 160° F (Chinese method) or steamed (Japanese method) This destroys the oxidizing enzymes Then they are rolled to break them up and liberate their juices, then fired " Oolong teas are partially withered at ordinary temperatures before the enzymes are destroyed by heat

It will be observed that the chief difference between black and green tea is that the former is fermented, while the latter is not, and one of the main results of fermentation seems to be to oxidize some of the tannin, so that as we shall shortly see an infusion of green tea contains more tannin than an infusion of black

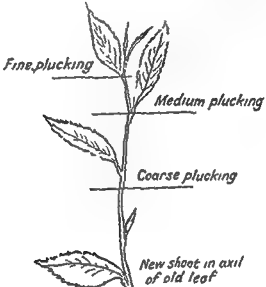

Fig 27

We have seen that the quality of teas varies with *the age of the leaf* from which they are prepared the younger leaves yielding tl finest tea Apart from this cause of variation teas show markc differences according to the country and district in which they a produced

Chinese teas have the most delicate flavour of any, but ar rather lacking in " body " they are also devoid of any marke astringency, i e they have less tannin

Indian teas, and especially those produced in Assam have th greatest degree of ' body ' and astringency *This makes* then powerful teas, suited rather for blending with milder varieties thar for drinking alone

Ceylon teas have plenty of body, and a rich and peculiar

flavour, but have not so much strength or pungency as the Indian varieties The best pluckings are made in February, March, August and September

According to the district in which they are produced, *Chinese black teas* may be divided into

1 Monings, from North China with a small and delicate leaf and a peculiar malty flavour They are called in the trade Black leaf congous

2 Kaisows from South China the so-called red leaf teas because the original teas grown in this district had a reddish leaf These are the Red leaf congous of commerce

3 Oolongs from Formosa and China are semi fermented teas, pungent and slightly bitter yielding a pale infusion and chiefly used for purposes of blending

4 Scented Orange Pekoe and scented Caper come from the Canton district They are scented by adding white jasmine gardenia, and magnolia flowers after the last firing and are allowed to stay in contact with these flowers for 24 hours They yield a pale strong infusion with an aromatic flavour for which reason they are used to give bouquet to blends Caper is an unfermented tea, highly fired and standing intermediate between the black and green varieties

Of *Indian black teas* those from the Darjeeling district are best being less rough and astringent than those from Assam and well adapted for drinking alone The best pluckings are made in June and October It should be remembered that most black teas in the market are really blends of Indian Ceylon and China in different proportions

Most *green teas* come from North China and Japan the latter yielding the best Very little is produced in India

Other countries producing teas are Indo China Burma Siam Java Sumatra and Kenya The U S S R are developing the cultivation of tea in the Caucasus

In *judging a tea* professional tea tasters are guided by the nature of the liquor and the characters of the infused leaves or out turn

The infusion should be of a reddish golden colour pungent in flavour but not too bitter or astringent and not thin ' or hard

The infused leaves should be of a bright coppery tint and evenly extracted so that some do not look darker than others they should be uniform in size and after five minutes infusion should not be completely unrolled There should not be too much stalk mixed with the leaves

Chemical Composition of Tea The following analyses of teas are given by Ukers [1]

Composition of Tea

	Per cent
Water	5 0 – 8 0
Caffeine	2 5 – 5 0
Nitrogen	4 75– 5 5
Soluble matter	[illegible] –45 0
Tannin	7 0 –14 0
Mineral elements	5 0 – 5 75

Of these ingredients the most important are the alkaloid *caffeine* and *tannin* for these, along with a small proportion of volatile oil (½ per cent) are the ingredients to which the chief effects of tea on the body are due The importance of the caffeine and tannin is so great that it may be well to bring forward some modern estimations of these ingredients in different teas which were made by Hosai [2]

Amount of Tannin and Caffeine in Tea (per cent)

	Dried Leaf	Green Tea	Black Tea
Crude Protein	37 33	37 43	38 90
Fibre	10 44	10 06	10 07
Mineral matter	4 97	4 92	4 93
Caffeine	3 30	3 20	3 30
Tannin	12 91	10 04	4 89
Hot water extract	50 97	53 74	47 23
Ether extract	6 49	5 52	5 82
Total Nitrogen	5 97	5 99	6 22

Indian and Ceylon teas are richer in all the chief ingredients (caffeine tannin and volatile oil) than China teas Green tea is richer in tannin than black but the amount of caffeine in the two is almost the same A high grade tea contains both more tannin and more caffeine than a low grade tea

The *composition of the infusion* is of much greater practical importance than that of the leaves from which it is made

If tea is infused for five minutes in the usual way, about 25 per cent of the weight of the leaf goes into solution In making a large teacupful of tea (about 150 c c , or ¼ pint), 5 grammes (about ⅙ oz) of dried leaf are usually employed and a cupful of such tea contains in solution about 1 gramme of solid matter The bulk of this is

[1] Ukers *op cit* I, 511
[2] Quoted by Ukers *op cit*

made up of gummy matters extractives etc, but the most important ingredients are the caffeine and tannin

Of these two ingredients the caffeine comes out much more readily than the tannin and the result of this is that second cups made from a further extraction of the leaves as is the usual practice, contain much less of the stimulant and more of the astringent than the first cup An illustration of this is seen in the comparison of the effect of 5 minutes infusion compared with one hour s boiling

	5 mins. Infusion	1 hour s Boiling
Tannin	7 3	12 4
Caffeine	3 6	4 8
Soluble extract	23 2	41 5

The practical inference is that if we wish to avoid having much tannin in tea and yet a high proportion of caffeine we should infuse it but for 5 or 6 minutes and then pour off the infusion into another teapot If less tannin is desired 3 minutes infusion is better

Hutchison made a number of experiments with the view of determining the amount of caffeine and tannic acid present in an ordinary teacupful of tea infused in the usual way The results are contained in the following tables

CAFFEINE IN TEAS [1]

Tea	Caffeine in Grammes per 150 c c			
Ceylon Pekoe	0 0787	equals	1 21	grains
Fine Darjeeling	0 0751		1 15	
Common Congou	0 0745		1 14	
Moyune Gunpowder (green)	0 0645		0 99	
Imperial Gunpowder	0 0590		0 90	
Household blend	0 0580		0 89	
Young Hyson	0 0547		0 84	
Fine Moning	0 0510		0 78	
Fine Assam	0 0475		0 73	

[1] Eight grammes of dry leaf were infused with 300 c c boiling water for five minutes The caffeine was estimated by Allen s method and the tannin estimated by Procter s modification of Löwenthal s process

TANNIN IN TEAS

Tea	Tannin as Gallo tannic Acid per 150 c c of Infusion		
Moyune Gunpowder	0 273	equals	4 20 grains
Young Hyson	0 242	"	3 72 "
Imperial Gunpowder	0 227		3 49
Ordinary black blend	0 173		2 66
Fine Darjeeling	0 168		2 58
Good black blend	0 168		2 58
Ceylon Pekoe	0 142		2 18
Lapsang Souchong	0 087		1 33 "
Fine Assam	0 080		1 23
Fine Moning	0 058	"	0 89 "

As a rule one may say that a teacupful of tea of ordinary strength infused for five minutes contains about 1 grain of caffeine, and from one and a half to three times as much tannin

It may be well to give some practical *rules for the proper method of making tea* based on the facts as to its chemistry which we have just been considering This is all the more important as it is *comparatively rare to get a really good cup of tea* in spite of the popularity of the beverage It must be admitted too, that *the fault lies oftener with the method of infusion than with the quality of the original leaf employed*

And first the tea should really be *infused* i e boiling water should be poured on the leaves and allowed to stand thus for five minutes The character of the water is of the first importance The Chinese rule is 'Take the water from a running stream, that from hill springs is best river water is the next and well water is the worst" The experience of one of us is that in this country rain water is the worst soft moorland water the next worst and water of the hardness of London water the best for tea making though tea dealers do not necessarily agree The water should have just come to the boil 'The fire must be lively and clear, but the water must not be boiled too hastily At first it begins to sparkle like crabs eyes then somewhat like fishes' eyes, and lastly it boils up like pearls innumerable springing and waving about' is the quaint advice of the Chinese

The quantity of leaf infused demands some attention The domestic rule of a teaspoonful for each person and one for the pot' is an uncertain one, for the weight of a spoonful of tea is a very variable quantity depending on the size of the leaves and the tightness with which they are rolled

Tea tasters use the weight of a new sixpence (43½ grains or

2·0 grammes) to 3½ oz of water and this, which is a somewhat smaller proportion of tea than that given by the domestic rule yields a more satisfactory though weaker infusion It must be remembered however that the popular taste is for a strong beverage with a good deal of body [1]

The use of a cosy during infusion does no harm but as soon as the process is completed the liquor should be poured off into another hot teapot, which may then be kept covered if desired

The addition of milk or cream though an outrage in the eyes of connoisseurs is to be commended on hygienic grounds for the protein of the milk combining with the tannin forms an insoluble compound

All second brews should be avoided for a single infusion is sufficient to remove from the leaves all the useful constituents of the beverage

COFFEE

Coffee was introduced into this country in the year 1652, by a certain Mr Daniel Edwards a retired Smyrna merchant, who set up his Greek servant in a coffee house the first of its kind in London in St Michael s Alley Cornhill [2] As a beverage it has never attained the popularity with us that it has won on the Continent This may be explained partly perhaps by the fact that we do not know how to make coffee but mainly by its greater expense when compared with its principal rival tea

Coffee is derived from the Coffæa arabica, originally produced as the name implies in Arabia but now cultivated in many tropical countries The plant produces three harvests annually the fruit resembling a cherry in which the coffee bean corresponds to the stone The bean consists of two halves placed face to face and enclosed in a husk The pulp is softened by fermentation and removed and the beans still enclosed in their husk are dried in the air The husk is separated by rolling and the beans are then separated from the delicate parchment like skin which covers them, and assorted according to size

[1] For the economical preparation of good tea the thorough crushing of the leaf is of great importance so that its ingredients may readily be extracted The powdered tea of Japan is ideal in this respect and in this country tea tabloids are deserving of a word of praise for the same reason

[2] According to UKERS (1935) *All About Coffee* The Tea and Coffee Trade Journal Co . Oxford anticipated London by two years

Varieties of bean are found on the market, the chief being as follows

1 *Mocha* The genuine beans of this are derived from Arabia, the best from the Beni Mattar country The beans are small, hard round, and irregular in form and size olive green to pale yellow in colour The roast is poor and irregular In the cup Mocha has a heavy body and smooth and delicious flavour (Ukers)

2 *Mysore* A general name for Indian beans The bean is small to large blue green in colour It yields a strong flavour and deep colour

3 *Kenya* Beans small and roundish with blunt ends and of a greenish colour The liquor is mild," with full body and of a flavour between that of Mysore and Costa Rica

4 *Costa Rica* A blue greenish berry yielding a fine, mild flavoured liquor rich in body

5 *Java* A very fine coffee with blue to pale yellow beans, yielding a smooth light coloured liquid

6 *Sumatra* The finest coffee the world produces Large uniform green beans Smooth heavy body almost syrupy

7 *Brazil* 60 to 70 per cent of the world s coffees come from Brazil, and 45 to 50 per cent from the Sao Paulo district Small bean resembling Mocha Smooth acid and pungent in the cup

In order to prepare the beverage the berries must first be roasted The composition of raw and roasted coffee is contrasted by Triggs, quoted by Ukers

COMPOSITION OF COFFEE

	Mocha, Green	Roasted
Caffeine	1 3	1 28
Water extract	31 27	30 44
Fat and oil	14 04	14 18
Protein	8 56	9 57
Crude Fibre	22 46	15 41
Mineral elements	4 20	4 43
Moisture	9 06	3 36

The chief physical change which results from roasting is that the berries are rendered brittle and can now be ground Chemically, one finds that they lose considerable weight the loss consisting in nearly equal parts of moisture and organic matter The lost organic matter includes some of the caffeine [1] If the coffee is 'over roasted," the loss of caffeine may be considerably greater

[1] The fat is not much affected according to BENGIS and ANDERSON (1934) *Journ Biol Chem* 105, 139 (quoted by UKERS) The Polenske and Reichert-Meissl figures rise

The aromatic substances which give its attraction to coffee are many, probably mainly heterocyclic metraptans.

Composition of the Infusion. From 25 to 35 per cent. of the coffee used in making the infusion goes into solution. This percentage of solubility is about the same as that of tea, but seeing that a much larger quantity of coffee is taken than of tea, the amount of solids per cup is considerably higher in the former than in the latter beverage. If 2 oz. are used to make a pint,[1] a teacupful of the beverage will contain in solution about 4.2 grammes of solids, of which 0.65 is mineral matter. This is supposing the coffee to be filtered. As ordinarily drunk, some suspended matter must also be included.

An analysis made by Hutchison of coffee of the above strength showed the presence of 1.7 grains of caffeine per teacupful and 3.24 grains of tannin.[2] According to this result, a cup of black coffee contains very much the same amount of caffeine and tannic acid as an equal quantity of tea. A breakfast cupful of *café au lait* is composed of about 1 part of black coffee to 3 of milk, and will not therefore contain more of the alkaloid than a teacupful of tea.

French coffee demands a special word of mention. It usually contains more or less chicory, and sometimes also some burnt sugar. Chicory is the root of the wild endive, kiln-dried and broken into fragments. The process of drying converts its sugar, of which it may have 10 to 18 per cent., into caramel. There is no reason to believe that chicory is in any way injurious to health, but its cheapness is a great temptation to use it as an adulterant, a process which has done much to discourage the consumption of coffee in this country. As a rule French coffee contains about one third of its weight of chicory, but sometimes the proportion may be as high as 80 per cent., or even more.

The secret of having good coffee is to make it *strong* and to make it *hot*. We mostly fail in this country by not using enough. One ounce to the pint is the smallest proportion which will give a good result. It is important that the coffee should be freshly roasted, or if bought roasted it should be bought in small vacuum sealed tins. If the beans are roasted and ground at home, they should be of one size or they will be unequally fired. Blending or mixing should be done after roasting. Its fragrance is quickly dissipated on keeping. Care also must be taken that the grinder is quite clean, for if *any stale coffee is left in it the whole may be spoilt*. The best way of making coffee is to extract the freshly roast and ground

[1] One ounce of coffee to the pint is usually, however, regarded as enough to make a satisfactory beverage.

[2] Reckoned as gallo tannin.

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coffee overnight with *cold* water, strain it and rapidly bring the extract to a temperature at which it is worth drinking Boiling an infusion alters the flavour The usual way is to pour boiling water over the freshly ground coffee The water should be just boiling, and infusion may be carried out either in a jug or in a porcelain percolator For breakfast coffee a mixture of coffees—e g half and half Mocha and Plantation—may be used, and the addition of a little *ground* chicory is liked by some but for black coffee the latter should always be omitted Three parts of milk to one of coffee is about the proper proportion for *café au lait*

Cocoa

Cocoa was first brought to Europe from Mexico by the Spaniards early in the sixteenth century [1] It was known as ' cacao, but the name got changed with the lapse of time Although introduced considerably earlier than either tea or coffee it is only of late years that it has attained any wide popularity, and that chiefly through the energy and enterprise of some of its manufacturers

The cocoa plant is the "Theobroma cacao," the fruit of which resembles a vegetable marrow or cucumber Embedded in the pulp of the fruit are many seeds each about the size of a haricot bean and it is from these that cocoa is prepared The seeds are separated from the pulp, and placed in heaps for several days to ferment or sweat '[2] This causes any adherent pulp to become loose, and at the same time modifies the bitterness of the seeds and produces in them a dark colour They are then roasted which renders them brittle and loosens the husk, so that the two halves of the seed come out separately on pressure in a machine as *cocoa nibs*

The nibs are either sold as such or are ground between hot rollers which, by melting the fat that they contain, reduces them to a fluid condition Much of the fat is removed by pressure, and the remainder of the cocoa is then run into moulds from which it is removed as slabs For conversion into soluble cocoa" or 'cocoa essence the slabs are ground to an impalpable powder

Various names are applied to different preparations of cocoa The method of preparing *soluble cocoa* has just been described, but it should be noted that the term is really a misnomer, for,

[1] For a history of Cocoa see *The Food of the Gods* by Brandon Head (George Routledge and Sons Ltd)

[2] If this is done in tropical sunlight the yeasts which cause the fermentation become endowed with vitamin D which may ultimately appear in the cocoa

strictly speaking there is no such thing as a soluble form of cocoa All that the term implies is that the powder is so finely divided that it easily remains in a state of suspension when mixed with water In order to aid the suspension, various methods of treating the cocoa are sometimes adopted The addition of alkali such as sodium carbonate is a favourite device especially with Dutch manufacturers It aids suspension by saponifying and emulsifying the fat, and at the same time softens the fibre of the cocoa so that it can form a sort of pulp with water It also has the effect of deepening the colour of the beverage and so of making it look stronger The free addition of alkali is objected to by some as being injurious to health but it is very doubtful if that can be fairly alleged against it There are also methods of increasing the solubility of cocoa by the aid of heat and to these no objection can be urged

The term *homœopathic cocoa* was originally applied to mixtures of cocoa with starch

Malted cocoa is a combination of pure cocoa with extract of malt

Chemical Composition of Cocoa [1] The general composition of the cocoa bean is shown in the following table

COMPOSITION OF COCOA

		Analysis of Raw Trinidad Nibs [2] Per Cent	Analysis of Shelled Fresh Cocoa beans [3] Per Cent.
Water		5 23	7 6
Fat		50 44	40 9
Starch		4 20	2 4
Albuminous matter	soluble	6 3	10 9
	insoluble	6 3	
Astringent principle		6 71	0 2
Gum		2 17	2 4
Cellulose		[illegible] 40	10 6
Alkaloid		0 81	3 3
Cocoa red		2 20	
Undetermined		5 80	5 3
Mineral elements		2 75	4 0

The chief ingredient is fat of which the cocoa bean contains about half its weight In the commercial powder, however there is only about 30 per cent present the remainder having been removed by pressure

Cocoa contains a considerable proportion of nitrogen but it must

[1] See also ALLEN'S *Commercial Organic Analysis* 3, Part 2
[2] Inland Revenue Laboratory [3] Boussingault

be carefully noted that not all this represents protein Part also is contained in theobromine

The chief alkaloid found in cocoa is theobromine [1] *Theobromine* is known chemically as dimethyl xanthine, and it is closely related to caffeine, which is trimethyl xanthine Cocoa contains from 1 to 2 or more per cent of it, or about as much as there is of caffeine in coffee

Cocoa contains also some tannin, though probably not of exactly the same form as that found in coffee and tea It seems to be combined with a pigment to which the name of cocoa red is given, but the exact relationship of the two substances has not been fully determined

Starch is present to the extent of 8 per cent (Winton, Silverman, and Bailey) [2]

The proportion of mineral elements is high amounting in raw cocoa to from 2½ to 3½ per cent Copper and manganese are present and iron 2¼ to 3½ milligrammes per 100 grammes After the fat has been partly removed, the proportion of ash rises to 4 or 5 per cent or, if alkali has been artificially added, it may amount to 8 per cent The ash is strongly alkaline, and in the artificial preparations consists chiefly of potash and phosphoric acid

Chocolate consists of ground cocoa nibs to which cocoa butter is added together with cane sugar and vanilla flavouring The inferior varieties are made from unfermented beans, and therefore have a bitter taste Good chocolate should melt easily in the mouth, and should not sweat out any sugar in the form of a bloom The taste also should be free from any roughness or astringency The white part of chocolate creams consists of a mixture of cane sugar and glucose

The table on the opposite page shows some analyses of cocoas drinking and eating chocolate

Uses of Tea, Coffee and Cocoa

Tea contains *caffeine* (1,3,7,trimethyl xanthine) and theophylline (1 3 dimethyl xanthine) [3] coffee, caffeine and cocoa, theobromine

[1] Analyses in 1935 from the laboratories of Fry & Sons show the presence of caffeine

	Beans	Cocoa	Plain Chocolate	Milk Chocolate
Theobromine	1 04 (0 82–1 32)	1 5	0 3	0 15 per cent
Caffeine	0 4 (0 14–0 73)	0 6	0 1	0 05 „ „

[2] Quoted by Winton and Winton (1939) *The Structure and Composition of Foods* Chapman & Hall Ltd 4, 121

[3] Also tetramethyluric acid (tetramethyloxyxanthine)

Bournville cocoa	18·1	26·5	36·0*	7·7	2·3	131	A typical modern cocoa powder
Cup chocolate	5·3	10·1	71·1†	1·4	about 0·4	140	A drinking chocolate in flake form.
Red Label chocolate	6·1	6·9	82·5†	1·6		121	A drinking chocolate in powder form
Bournvita	13·1‖	8·1§	72·3‡	3·0	—	120	Combination of malt, milk, egg and chocolate powder
Cocoa and milk powder	12·1‖	5·7§	76·2‡	3·3	about 0·4	118	A sweetened blend of cocoa and milk solids.
Bournville chocolate	4·1	32·5	59·9†	1·2	0·4	160	Eating chocolate
milk chocolate	8·0‖	35·0§	53·0‡	2·0	0·3	161	Eating chocolate
Rowntree's Elect cocoa	17·1	24·0	39·0¶	7·[illegible]	2·3	130	An alkalized cocoa essence
plain chocolate	4·8	32·6	60·8	1·3	0·37	146	Made from cocoa nibs, sugar and added cocoa butter
milk chocolate	8·3‖	33·5	55·1	1·7	0·19	146	Cocoa nibs, sugar, full cream dried milk and added cocoa butter
Fry's plain chocolate	3·4	32·1	61·4†	0·8	0·5	160	3 per cent of the fat is butter fat. 1·2 I.U. vitamin D per gramme chocolate
milk chocolate	8·2‖	33·7	65·2‡	1·6	0·2	162	Vitamin A = ½ that of early summer butter. Vitamin D 9 I.U. per oz. chocolate
Breakfast cocoa	17·4	23·0	39·8	7·4	2·9	124	
Malted milk cocoa with eggs	14·8	8·6	67·7	3·9	0·6	119	
Supox chocolate	5·6	35·3	46·5	1·4	—	132	Free from cocoa shell or starch and added alkali. Of good texture, free from astringency and bloom. (*Lancet*, 1922.)
Vienna drinking chocolate	5·1	6·8	82·0†	1·8	0·9	119	

(3,7,dimethyl xanthine) Of these much the most active and important is caffeine

Caffeine is a stimulant which affects the nervous system and the kidneys In the nervous system it influences the higher "psychic" centres more than the medullary centres and these more than the spinal cord Pavlov states that it is impossible to inhibit conditioned reflexes when the animal is under the influence of caffeine, and the alkaloid has therefore an effect on the cortex of the brain It undoubtedly "clears the mind,' abolishes a sense of fatigue and often induces sleeplessness Tea and coffee certainly are great aids to mental work, and the former, as de Quincey remarked, will always be the beverage of the intellectual For panegyrics on tea and coffee and legends concerning the discovery of these plants the reader is referred to earlier editions of this book and to the books by Ukers

Respiratory and cardiac centres are also stimulated by caffeine and there is a direct effect on the coronary arteries, which are dilated The basal metabolism of a group of coffee drinkers was found to be 6 per cent higher than that of a control group of abstainers from coffee [1] It is also said to raise the blood sugar level As a result of the quickening of respiration, the alveolar carbon dioxide is lowered Apart from its action in improving the circulation of blood it causes diuresis by direct action on the kidney It decreases the reaction time and the latent period of reflexes and stimulates the capacity for muscular work [2] It is not cumulative nor habit forming and it has no after effects The other purine derivatives have rather less effect than caffeine, but the action is similar

Clearly these alkaloids are extremely useful and their effects account for the very extended use of the beverages containing them by people in all ages and countries On the other hand their pharmacological properties are too mild seriously to interest pharmacologists and clinicians to day for much more potent drugs have been discovered [3]

The common practice in this country among the well to do is to take tea at afternoon tea only, and coffee at breakfast after lunch and after dinner Nearly everyone lower in the social scale takes tea at breakfast and in the afternoon and possibly before breakfast at midmorning after the midday meal with the evening meal and perhaps just before bed In Canada and probably in other Dominions, it is drunk with each of the three meals

[1] Hackett (1931) *Journ Home Econ* 13, 769
[2] Rivers and Webber. (1907) *Journ Physiol* 36, 33
[3] The late A J Clark *Private communication*

There is a strong medical prejudice against taking tea with any meat meal in Great Britain, and the belief is entertained that the tannin in the tea tans the protein of the meat and makes it indigestible. But no objection is raised to the tanning of the protein of fish and eggs at breakfast, which must be almost as serious, nor to the effects of tannin in coffee or wine. Attempts have been made to justify objections to the taking of tea and coffee at meals by experiments *in vitro* and *in vivo*.

Thus *in vitro* the presence of tea inhibits the digestion of boiled starch to maltose by the ptyalin of the saliva. This inhibition seems to be due to the tannin, for it is less with a good China tea than with an Indian tea, with its higher content of tannin, and the effect disappears entirely if milk be added, which combines with the tannin and puts it out of action. When the tannin[1] is in combination with the caffeine and not free it is said to exert less effect in precipitating and rendering protein insoluble.

In vivo it has been claimed by a succession of workers that tea and coffee delay peptic digestion, although Miller and his colleagues[2] found that the emptying of the stomach is not appreciably delayed by 1 litre of tea or coffee, and that a delay apparently caused by an equal quantity of cocoa is due to the sugar normally taken with it.

As regards the practical inferences to be drawn from these and similar experiments, it may be said that in health the disturbance of digestion by these infused beverages is negligible. Only when the digestion is enfeebled or when the patient is sensitive to tea or coffee is caution necessary. It is usual to restrict the consumption of tea and coffee in gastritis, gastric and duodenal ulcer. It may be wise to forbid coffee entirely and recommend that weak China tea, freshly infused and poured off the leaves, be taken at the end of the meal in its place not more than twice a day. These beverages should not be taken on an empty stomach.

When we turn to the question to what extent these beverages can be indulged in without injury to health, we find it very difficult to give a definite reply. The part played by personal peculiarity and habit in the matter is very great. It has been pointed out, for example, that the usual result of drinking tea and coffee is to produce wakefulness, but yet there are persons who find their use in the evening conducive to sleep. Some people, again, can drink tea quite freely, but are made ill by coffee, or *vice versâ*. Facts like these must be recognized although one is unable to explain them,

[1] Hyjat tea contains all its tannin as caffeine tannate according to analyses by the Royal Institute of Public Health and Hygiene.
[2] MILLER *et als.* (1920) *Amer. Journ. Physiol.* **52**, 28.

Alcohol, unlike any other fluid or food, is very rapidly absorbed through the walls of the stomach, and while there is no evidence that it carries with it the products of digestion, it can carry substances like chloral and strychnine more rapidly into the blood stream

Metabolism and Alcohol

That alcohol can act as a *food* is undoubted, but it acts as a Calorie food only It cannot take the place of proteins, inorganic elements, or vitamins In the form in which it is usually taken, beer, wines, or spirits, it contains little or no vitamins though there is evidence that vitamin B_1 in small amounts is found in some beers (3 units per 100 c c)[1] There is so little protective effect in alcoholic beverages that they induce neuritis by decreasing the intake of foods containing vitamin B_1

Consequently, the consumption of alcoholic beverages can be defended only on the grounds that alcohol can be burnt by the tissues of the body with the production of Calories It is completely absorbed, partly in the stomach but mainly in the small intestine, and it is absorbed more rapidly than almost any other food It reaches its maximum concentration in the blood in from ½ to 2 hours[2] The concentration in the blood depends upon the concentration in the fluid drunk

The rapidity with which it enters the bloodstream is greatly decreased by taking it with food, especially with foods containing fat

One fiftieth to one tenth of the alcohol drunk may be excreted in the breath and in the urine The remainder is metabolized, i e burnt to carbon dioxide and water The rate of combustion is somewhat slow, being about 7 c c of absolute alcohol per hour, i e the amount found in 100 c c of a mild claret But it can be used to supply energy and to "spare" protein just as carbohydrate can "spare" protein As it enters the blood so rapidly and as it needs no preparation for combustion, it can conceivably be used in emergencies when it is necessary to give a person, who has exhausted his store of carbohydrates rapidly available fuel material

Pharmacology of Alcohol

Alcohol is usually referred to as a ***stimulant*** This is a misnomer Throughout the body, particularly in the nervous system it acts as a depressant It produces its euphoria by blunting self criticism It weakens self-control, dulls sense perception and

[1] Boas Fixsen and Roscoe (1937) *Nut Abs and Rev* 7, 823 Riboflavine and nicotinic acid are found in beers

[2] E Mellanby (1919) *Med Res Comm Spec Rep* No 31

impairs the accuracy of skilled movements "Under the influence of alcohol accuracy avoidance of accident tactful handling of colleagues and subordinates observance of discipline, punctuality, reticence in matters of confidence are all jeopardized "[1] It is, in fact, a narcotic

There is little or no satisfactory evidence that it has any effect on the respiratory system of practical value In small doses it does not alter the rate of beat of the isolated heart and in large doses it decreases that rate Its influence on the actual blood pressure is small It does, however, dilate the superficial blood vessels and so may as a secondary effect increase the pulse rate

When alcohol appears to promote recovery from fainting it is probably because strong spirit has been given, resulting in a painful stimulus to the mucous membrane Painful stimuli wherever applied—e g smelling salts to the nasal mucous membrane—have a similar beneficial effect

Whenever alcohol has an apparently restorative effect in disease, this is due to localized stimulation or a generalized narcotic and sedative action To day there are other more powerful and valuable drugs in the pharmacopœa

As is well known its effect in apparently raising the temperature is illusory It certainly makes a person feel warmer, but that is because of the dilatation of the blood vessels of the skin The feeling of added warmth is deceptive What is really happening is that the alcohol increases the loss of heat from the body People frozen to death have often met that fate through having been drunk when the cold overtook them

Alcohol in Dietetics

There is little then to be said in favour of alcohol and alcoholic drinks either from the dietetic or medical standpoint Medical opinion is reflected in the very marked decrease in the use of alcoholic drinks in hospital practice as is reported elsewhere in this book (pp 582–4) Dietetics rarely pays them much attention The utmost that can be said for them is that (1) they have acquired the value of a social gesture of hospitality, (2) they are pleasant drinks to those accustomed to them, and (3) they promote a pleasant euphoria, which however is not without its dangers to people with an escapist ' tendency[2] According to McDougall alcohol enables the introvert to become extravert[3] People who are used

[1] *Alcohol its Action on the Human Organism* 3rd edn (1938) 45

[2] The death rate from alcoholism is only one eighth of what it was in 1901 and from cirrhosis of the liver only one fifth *ibid*

[3] McDougall (1944) *An Outline of Abnormal Psychology* 4th edn

to alcohol may often be allowed it in their diet when they are special diets, because they are miserable without it and the mis produces a more deleterious effect than the alcohol

ALCOHOLIC BEVERAGES

Before proceeding to the study of the alcoholic beverages in det it may be well to describe the different ways in which the amou of alcohol which they contain may be stated This is all t more important as an inaccurate use of terms may lead to sor confusion

In this country the standard employed is usually what is know as *proof spirit* and an alcoholic liquor is said to be so much abo or so much under "proof" Proof spirit is a mixture of alcoh and water, which contains 49 28 per cent of the former by weig (i e 100 grammes contains 49 28 grammes alcohol) [1] and 57 10 p cent by volume (i e 100 c c contains 57 10 c c alcohol) Th name proof spirit owes its origin to the practice in vogue durin last century, of testing the strength of samples of alcohol by pourin them on to gunpowder and applying a light *If the sample con tained much water the alcohol burned away, and the water mad the powder so damp that it did not ignite but if the spirit wer strong enough the powder took fire A sample which just suc ceeded in igniting the powder was called proof spirit* ' (Perkin and Kipping) Spirits are described as being *over proof* when they are stronger than proof spirit and *under proof* when they are weaker Thus 20 over proof means that 100 volumes of the spirit contain as much alcohol as 120 of proof spirit, and 20 under proof means that 100 volumes only contain as much alcohol as 80 of proof spirit

Instead of using proof spirit as the standard it is more conven ient to speak of the amount of alcohol as being so much *per cent* The percentage may further be stated either in weight or in volume Five per cent of alcohol by weight means, strictly speaking, that 100 grammes of the liquid in question contain 5 grammes of alcohol but more usually the expression is used for weight in volume— i e 5 grammes of alcohol in 100 c c Five per cent by volume means 5 c c in every hundred, and is equivalent to about 4 per cent by weight [2] The average percentage of alcohol by volume

[1] 100 grammes of proof spirit has a volume of about 110 c c, for shrinkage occurs when water and alcohol are mixed

[2] c c alcohol in 100 vols × 0 8 = grammes in 100 vols
Grammes alcohol in 100 vols × 1 25 = c c in 100 vols
" " in 1 litre × 7 = grains per gallon (6 bottles)

in some of the commoner alcoholic beverages is roughly as follows [1]

SPIRITS		
Gin, Whisky Brandy Rum	25 under proof	43
	35 "	37
WINES:		
Port		20
Sherry		20
Madeira		20
Burgundy		14
Champagne		10
Claret		10
Hock		10
Vermouth		14–20
Empire wines		15–22
British wines		10
CIDER (Bottle)		4 2
BEER (English):		
Ale		3 1–6 6 [2]
Stout		3 9–5 3
Porter		4 0

In France and most other countries the amount of alcohol in wines is estimated by volume and is expressed in " degrees " Thus a wine of 10 degrees strength contains a tenth of its volume of alcohol

Spirits Spirits are obtained by the fermentation of various saccharine substances, the alcohol and other volatile bodies produced being separated by distillation It is this fact of their being the products of distillation which gives to spirits their high alcoholic strength and distinguishes them from all other alcohol containing beverages Almost any substance capable of yielding a fermentable sugar may form the basis of fermentation Amongst the substances most commonly used in this country are malted and unmalted barley, maize, rice sugar and molasses In some parts of Europe and especially in Russia potato starch is largely employed for the purpose All of these substances yield alcohol on fermentation but in addition various by products make their appearance during the process and it is to the presence of these that the characteristic flavour of the different spirits is due

Thus the by products of the fermentation of malted barley give rise to the flavour of whisky those of molasses to the flavour of rum,

[1] Quoted from *Alcohol its Action on the Human Organism* (1938) H M S O,

[2] Less in war time

and those of the grape to that of brandy By means of patent stills the by products can be almost entirely separated from the alcohol with which they are mixed, and the result is an almost pure form of spirit, the origin of which can scarcely be told, for which reason it is called ***silent spirit*** By suitable flavouring the clever manufacturer can make this the basis of almost any spirituous drink

Among the by products of fermentation there are usually found small amounts of alcohols of a higher molecular weight than ethyl alcohol These are isoamyl, δ amyl propyl and isobutyl alcohols among others and to a mixture of these the term ***fusel oil*** is often applied This fusel oil is the result of the action of the yeast upon the amino acids of the substrate upon which it works If there is much isoleucine in the substances fermented (as, for example in molasses used in the production of rum) δ amyl alcohol will be found in the spirit produced, if more leucine than isoleucine, as in a mash of corn and potato, then isoamyl alcohol will predominate in the fusel oil formed when that mash is fermented[1] We shall see immediately that fusel oil and the other by products met with in spirits have effects on the body in health and disease only second to that of the ethyl alcohol itself

Whisky has been defined as 'a spirit made from malt or malt and grain, and distilled in pot stills'[2]

It is important to distinguish clearly between genuine 'malt whisky,' which is made in pot stills' and 'grain whisky," which is prepared in patent stills The bulk of ordinary whisky as it reaches the consumer is probably a blend of these two grain whisky usually predominating

(a) ***Malt whisky*** is prepared from malted barley which is first carefully dried In many Highland distilleries peat is used as the fuel for drying, and some of the characteristic flavour of such whisky is believed to be derived from the peat smoke After being dried the malt is made into a mash, and here, just as we shall see is true of beer the nature of the water used seems to have some influence on the character of the final product, soft water giving the best result The mash is then fermented much as in the making of beer only the process is allowed to go on longer When fermentation is complete, the fermented mash or "wash is distilled in the old fashioned pot still This is the form of still which is by far the most commonly used in Scotch and Irish distilleries It is made of

[1] Harden (1932) *Alcoholic Fermentation* 176 *et seq*

[2] The Royal Commission on Whisky and Other Potable Spirits which reported in 1909 however concluded that the term whisky may legitimately be applied to the product of a patent still also

copper, and the volatile products are condensed in a simple "worm," no attempt being made to separate the spirit from the by products The still is heated over an open flame This is a point of some importance for it causes some of the sugary substances in the wash to become slightly charred and there is produced in this way, amongst other things the substance furfural, the presence of which is one of the chief distinguishing characteristics of pot-still whisky

The first product of the distillation is called *low wines* These are redistilled and yield (1) "fore shots" (2) "clean spirit" or whisky, (3) "feints", the residue in the still being the "spent lees"

The fore shots and feints both contain much of the by products of fermentation, and are redistilled the distillate being added to the clean spirit, or whisky

It must be noted that fusel oil is not obtained separately by this method of distillation and the product consists of alcohol plus some of the by products of fermentation The whisky thus produced has an alcoholic strength of from 13 degrees to 50 degrees over proof but before bonding it is usually diluted in Scotland to 11 degrees and in Ireland to 25 degrees over proof

The by products—chiefly aldehydes—which it contains give it, when young a raw, harsh disagreeable taste but after keeping for some years in wood it mellows greatly, and the harsher the taste when young the more full flavoured the whisky when matured

What the exact nature of the changes is by which the improvement which whisky undergoes in wood is brought about we do not yet fully know This we do know, however, that the percentage of alcohol diminishes, 6 to 8 per cent of proof spirit being lost by five years storage On the other hand the fusel oil does *not* undergo diminution, in spite of frequent statements to the contrary

Irish pot-still whisky differs from Scotch in being prepared usually from a mixture of malted barley with unmalted grain (barley or maize) and the malt is not dried over peat Otherwise the manufacture of the two is very similar

(*b*) *Grain Whisky* This is the form of whisky most commonly distilled in England It is made from a mixture of grains (barley, rye and maize) with just a sufficiency of malt to convert their starch into sugar More important than this distinction however, is the fact that it is distilled by steam and in a patent (Coffey's) still in such a way that the by products of fermentation (fusel oil, etc) are to a large extent separated from the ethyl alcohol The result is that the raw product has much less flavour than young malt whisky and is sooner ready to go into consumption When run off the still it is almost colourless and has an alcoholic strength of 60 degrees over proof but is usually diluted to 11 to 12 degrees

over proof before bonding It acquires a yellowish colour from being stored in old sherry casks

As regards the main differences between the two varieties of whisky, it should be stated—

1 That patent still whisky contains much less of the by products of fermentation (including fusel oil) than pot still whisky, and is therefore much purer

2 That as a consequence of this patent still whisky does not improve nearly so much on keeping as the other variety

It follows from this that a young patent still whisky is much better to drink than *young* malt whisky but that the latter, when fully matured, has a fuller and pleasanter flavour than the former It is absurd to object to grain whisky on the ground that it contains more fusel oil than malt whisky for just the reverse is the truth After removal from bond whisky is diluted—or ' broken down as it is termed in the trade—by the addition of water The legal limit of dilution is 35 degrees under proof (about 37 per cent alcohol by volume), and most whisky is sold at a strength of about 30 under proof In other words we shall not go far wrong if we regard a glass of whisky as containing something between a third and a half of a glass of absolute alcohol *This is not true of war time whisky for the statutory dilution was increased*

As already mentioned, most commercial whiskies are blends, and not the product of one distillery Grain whisky is often used as the basis of the blend, a certain proportion of malt whisky being added to give flavour Even when the blend contains as much as 90 per cent of grain whisky *it is often sold as "genuine malt"* The public taste now is certainly in favour of a mild flavoured whisky, hence the large use of grain spirit in blends

Potheen is the product of illicit stills and, being usually made from molasses has the characteristics of rum rather than those of true whisky

Brandy If whisky is regarded as distilled beer, brandy may be spoken of as distilled wine

The best brandy was originally produced in one of the richest wine districts of France (Département de la Charente or Cognac district) The quality varies with the character of the grapes the best grapes yielding the variety known as Fine or Grande Champagne This is the *only* genuine liqueur brandy The varieties known as Petite Champagne and Première Bois rank next to it If sold pure these constitute old Cognac but a large amount of them is used for blending with inferior varieties

In a good year six or seven bottles of wine should yield one bottle of brandy When first distilled the spirit is devoid of colour and

of a fiery character When kept in cask it takes up colour from the wood and gradually becomes mellower Improvement goes on for a long time, so that the older the brandy the better After twenty or forty years it contains a considerable proportion of volatile esters and aldehydes to which it owes its aroma and flavour French brandies have a 0·02 per cent of a clear yellow oil with a powerful odour of cognac It is a natural ingredient and absent from all other types of brandies[1]

While the above is the origin of genuine brandy, it must be admitted that very little of the brandy sold in this country is so derived The greater part of it is really concocted in the Cognac district and elsewhere from silent spirit coloured with burnt sugar and flavoured with œnanthine or various essences Such a product is entirely different from genuine brandy for it contains but little of those volatile esters derived from wine which are so conspicuous in genuine Cognac and to which it owes most of its attraction

The production of genuine brandy by the distillation of Spanish wines is now carried on at Jerez and elsewhere It is also exported by Algiers Australia, Egypt and Greece, and some British Brandy is manufactured in this country from grain spirit, mixed with argol, French plums and French wine vinegar, the mixture being subsequently redistilled

In the United States brandy may be made from cherries, apples pears, and peaches as well as from grapes

Rum Rum is usually produced by the distillation of fermented molasses obtained in the manufacture of raw sugar, the best varieties, however, are obtained by direct fermentation of the juice of the sugar cane Pineapples and guavas are sometimes added to the fermented mash to improve the flavour of the distilled spirit This spirit contains by products of fermentation which impart to rum its characteristic flavour The chief of these is ethyl butyrate and a considerable proportion of the rum sold in this country is made from silent spirit flavoured with that substance

Rum owes its dark colour to burnt sugar When kept for some time it improves greatly in flavour by the development of esters in which it is peculiarly rich It usually goes into consumption at about the same alcoholic strength as whisky, or perhaps a little stronger

Gin (also known as Geneva—from *genièvre* a juniper—Schiedam and Hollands) is obtained by fermenting a mash of rye and malt,

[1] VALAER (1939) *Ind Eng Chem* 31 339 and *Journ Inst Brew* 45, 266 quoted in *The Analyst* 64 (1939)

and distilling and redistilling the product Juniper berries and a little salt and sometimes also coriander, cardamoms and angelica root are added in the final distillation, and the product is run off into underground cisterns lined with white tiles, where the spirit can be kept without colouring Some is matured in *old sherry* casks and becomes as a result straw coloured

The chief seat of the manufacture of genuine gin is at Schiedam in Holland Much so called gin, however is fabricated elsewhere out of silent spirit flavoured with salt juniper berries, and turpentine

Gin is allowed to be sold with as low a proportion of alcohol as 35 under proof (37 per cent alcohol by volume), but is usually imported at 14 to 15 under proof Sweetened and diluted gin is sold under the name of *Old Tom*

Whilst varying somewhat in alcoholic strength all the spirits we have been considering agree in containing very little solid matter—less, indeed than 1 per cent gin being the poorest in this respect They have also a very low degree of acidity rum standing highest then brandy, with 1 grain per ounce while whisky and gin have only about 0 2 grain per ounce They are all practically free from sugar

The following table taken from the *Report of the Lancet* Special Analytical Commission on Brandy represents the comparative composition of the different spirits in a convenient form

Constituents	Grain Spirit	Beet Spirit	Jamaica Rum	Scotch Whisky	Gin.	Typical 3-Star Brandy
Alcohol per litre by weight in grammes	932 60	912 90	619 20	436 20	401 50	410 50
Alcohol per litre by volume in c c	956 00	942 00	695 00	512 00	475 00	485 00
Equal to proof spirit per cent	167 55	165 09	121 79	89 77	83 26	84 96
Extract per litre	*Nil*	Nil	6 36	1 16	0 52	6 70
Acidity (calculated as acetic acid)	2 40	4 80	122 40	3 60	19 20	37 50
Aldehydes (as ethylic aldehyde)	1 15	10 92	15 41	14 38	4 72	6 10
Furfural	Nil	Nil	2 09	1 94	0 13	0·8*
Alcohol in esters (not in total)	1 84	9 20	161 00	20 24	4 60	2 88
Esters (expressed as ethyl acetate)	3 52	17 60	308 00	38 72	8 80	53 35
Higher alcohols	2 80	6 95	62 58	122 76	13 2.	58 48

Liqueurs and Bitters

This group of liquors may be regarded as consisting essentially of spirit sweetened with cane sugar and flavoured with aromatic or other herbs or essences. It has been well said that they are chiefly the product of the alchemist and the monastery. The proportion of alcohol in them is high, varying from 33 to 50 per cent or more by volume. The proportion of the other ingredients is shown in the following analyses of some of the most prominent members of the group, taken from König.

PERCENTAGE OF COMPOSITION OF LIQUEURS

	Alcohol		Extract	Cane sugar	Various extractives	Mineral matter
	By vol	By weight				
Absinthe	58 03	—	0 18	—	0 32	—
Angostura	49 70	—	5 85	4 10	1 69	0 068
Anisette	42 00	30 7	34 82	34 44	0 38	0 068
Benedictine	52 00	38 5	36 00	32 57	3 43	0 400
Chartreuse	43 18	—	36 11	34 37	1 76	—
Crême de Menthe	48 00	36 5	28 28	27 63	0 65	0 043
Curaçoa	55 00	42 5	28 60	28 50	0 10	0 040
Kümmel	33 90	24 8	32 02	31 18	0 84	0 058

The following is a brief description of the origin and constituents of some of the better known liqueurs and bitters.

Absinthe. Made by macerating Alpine plants of the wormwood species with the root of anise and sweet flag and marjoram leaves in 40 per cent spirit. A glassful (30 c c) contains the following amounts of absolute alcohol:

Ordinary absinthe	14 3 c c
Demi fine	15 0
Fine	20 4
Suisse	24 2

The toxic substance is thujone, a ketone isomeric with citral.

Curaçoa. Made in Amsterdam from the rind of bitter oranges grown in the island of Curaçoa.

Kirsch. Made from morello cherries in the Black Forest and containing a small amount of hydrocyanic acid.

Noyau Made from the *stones* of cherries, containing oil of bitter almonds and therefore poisonous

Maraschino Made by fermenting a small sour cherry *(marasca)* grown in Italy and Dalmatia Both the cherries and the stones are crushed and 10 per cent of honey added, and the whole fermented The spirit is diluted, and kept for some months to mature

Kümmel Consists of brandy flavoured with cumin and carraway seeds

Chartreuse Originally made at the chief Carthusian monastery near Grenoble in France, and also at Florence It contains a large proportion of sugar, the flavour being derived from various oils contained in angelica hyssop, nutmeg, peppermint, and other herbs

Benedictine is a very similar product, made at Fecamp in Normandy

Angostura is now chiefly made in Trinidad but formerly at Angostura, the chief flavouring ingredient being the bark of that name, though other species are also added

Ratafia is a name now applied in France to various liqueurs made from spirit sugar, and aromatic herbs It derived its name from the fact that it used to be drunk at the ratification of compacts and bargains

In practical dietetics the importance of liqueurs is small Diabetics must take into account their content of sugar Their use after a meal may be defended on the grounds of their carminative effect

In studying the ***general action of spirits on the body*** one must distinguish carefully between the action of the alcohol itself and that of the by products of fermentation which occur along with it It would be a great mistake to regard spirits as simply mixtures of alcohol and water in nearly equal proportion

Spirituous liquors are too highly alcoholic for ordinary dietetic use unless taken in great moderation and freely diluted Two or three glasses of whisky or brandy contain as much alcohol as most people can safely consume in one day If this limit is observed however and the spirit freely diluted they may do little physical harm

Why a matured spirit has less deleterious effects than a crude one is still unknown It was supposed once to be due to the "fusel oil, the mixture of propyl amyl butyl and isobutyl alcohols in the spirit They, however though much more toxic than ethyl alcohol are not present in sufficient amounts to take effect Possibly the deleterious substance is furfuraldehyde or pyridine

Malt Liquors

This group includes beer or ale and porter or stout There is some confusion in the use of these names, and they have not quite the same meaning in all parts of the country In some places the term ale " is applied to the brown beverages while the black drinks are spoken of as 'beers ' It is better to regard the terms ' ale ' and beer " as synonymous as they were in Anglo Saxon days and to apply them to the paler liquors and to speak of the blacker drinks as stouts or porters ' With the introduction of hops into English brewing the term ' beer ' began to mean ' hopped malt liquor

Beer may be defined as the product of the fermentation of malt and hops We shall see later that much of the ' beer ' in common use has not, strictly speaking, quite this origin

Malt is obtained by moistening barley and allowing it to germinate first in heaps and later spread out evenly on a floor of cement or tiles at a moderate and regular temperature During germination important changes take place the ferment diastase appears in the grain and acts upon some of the starch, converting it into dextrin and malt sugar while part of the proteins by the action of another ferment, is also converted into soluble forms The " green malt so produced is next dried, and upon the exact temperature at which this is carried out, the character of the beer largely depends for the lower (within limits) the temperature employed, the more powerful is the action of the ferments contained in the grain and the larger the amount of soluble substances produced Low-dried malts produce pale beer those dried at a higher temperature yield a darker product

When drying is complete, the malt is ground and made into a mash with water The soft water of Dublin in part accounts for the fame of Dublin stout but the water of Burton upon Trent, which contains much calcium sulphate or permanent hardness, is clearly one of the main causes of the pre eminence of the pale strong and export ales of that town In some breweries the water is artificially made up to the standard of that locality

After mashing the wort is strained off from the malt and boiled for an hour or two with *hops* Boiling stops any further action of the diastase and extracts from the hops their soluble ingredients Chief amongst these are hard and soft resins tannin and essential oils The resins are antiseptic and are necessary in beer for preventing the growth of various moulds wild yeasts and other micro organisms The resins and tannin give hops a bitter flavour The antiseptic properties of the resins are due to two acids, humulon

COMPOSITION OF MALT LIQUORS (PER PINT)

	Alcohol	Protein	Fat	Available Carbo hydrate	Cal cium	Iron	Phos-phorus	Calories
	c c	g		g	mg	mg	mg	
Pale ale draught	33 7	1 7	Trace	17 9	61	0 28	120	310
Pale ale bottled	34 5	1 1		16 8	76	0 39	99	308
Mild ale draught	25 2	2 8		17 4	66	0 28	[illegible]	252
Mild ale bottled	26 8	1 7		20 7	71	0 45	101	273
Strong ale	45 0	2 8		27 4	95	0 56	160	4[illegible]8
Stout	26 7	2 2		23 0	58	0 78	130	283
	Beers during war time were distinctly more dilute[1]							
Mild	17 3	1 2	0	9 7	57	0 58	—	16[illegible]
Bitter	24 4	1 2	[illegible]	9 7	57	0 58	—	216
Stouts	23 2	2 8	0	19 7	29	0 58	—	256
Strong ales	32 9	2 8	[illegible]	19 7	29	0 58	—	3[illegible]4

to this fact in the House of Commons[2] Doubtless the brewing industry will focus attention on it in the future While the ribo flavine content is comparable with that of milk the nicotinic acid content is much greater Even war time beers gave figures running from 7 8 to 17 0 *microgrammes per gramme or about* 4 42 to 9 65 milligrammes per pint Pre war beers contained more Thus Worthington Strong Ale brewed 1798, contained 9 36 Anglo Bavarian Beer, brewed 1872, 5 84 Reid s Stout, brewed 1899 9 8, and Combes Export Brown Stout brewed 1900 8 68 milligrammes per pint It is interesting to note that 'Chancellor' ale brewed for All Souls College Oxford, 1938 possessed 25 9 milligrammes per pint, i e more than a day s ration

ACTION AND USES OF MALT LIQUORS

Action on Digestion Malt liquors have but little retarding influence on salivary digestion and what action they do possess is entirely due to their acidity Stout is twice as acid as beer, and hence has a greater retarding action on the digestion of starch by the saliva[3] Sound beer indeed in some experiments,[4] seemed actually to increase rather than restrain the action of ptyalin *in vitro*, but sour beer has a decidedly retarding effect[5] On the other hand in the living body the bitterness of beer may bring about a

[1] *The Nutritive Values of War time Foods* (1945) Medical Research Council

[2] *Lancet* (1944) 2 226

[3] CHITTENDEN and MENDEL

[4] AITCHISON ROBERTSON (1898), *Journ Anat and Physiol* 32 615

[5] ROBERTS *Digestion and Diet* p 119

more profuse flow of saliva and so end by improving rather than impairing salivary digestion

In the stomach beer does not remain, if taken alone, any longer than water, for 200 c c are found to have completely left it in about one and a half hours If taken with other food, it delays the chemical processes of digestion more than the mere amount of alcohol which it contains will explain Some[1] have blamed the extract for this, others the salts[2] but the action is, in any case not an important one for even half a litre of beer (about a pint), when taken with a mixed meal was found to produce but very little delay in the stomach[3] It is probable indeed, that a tumblerful of good brisk beer may actually aid digestion by increasing appetite and calling out a more abundant secretion of gastric juice and more active movements of the stomach Both stout and beer are frequently prescribed as soporifics

Influence as Foods Since malt liquors contain digestible carbohydrates they must be rated as foods A pint of good ale contains as much carbohydrate as 1½ oz of bread It will be seen from the tables that a pint of even war time beer will give 165 Calories or about one twentieth of the total energy required per day

A glass of milk yields about 184 Calories a similar glass of good bottled beer about 168 It does not follow from this however, that beer is almost as good a source of energy as milk for, as we have seen alcohol is to be regarded as a food of only limited value Still less is it as good a food for it lacks any first class protein and is deficient in calcium iron and phosphorus and in most of the vitamins What energy it provides is purchased at more than twice the cost of that from milk Whatever may be the grounds for advocating the consumption of beer they can hardly be said to be dietetic or economic

Malt liquors must be strictly forbidden in many forms of disease The combined effects of their alcohol and carbohydrates render them specially prone to produce obesity and they have been regarded as frequent predisposers to gout In all cases of inflammation of the mucous membrane of the genito urinary tract also they seem for some reason, to have a peculiarly bad effect and the recurrence of a gleet for instance can often be traced to their use When taken by diabetics consideration must be given to the carbohydrate content Thus a pint of pre war beer contained 16 to 20 grammes carbohydrate and was equivalent to 1 or 1½ oz of bread War

[1] SIMANOWSKY (1886) *Arch f Hygiene* 4, 1

[2] BUCHNER (1881) *Deut Archiv f Klin Med* 29 537

[3] BUCHNER, *op cit*

beer contains much less carbohydrate and a pint is equivalent to about ⅔ oz of bread Similar considerations apply in the treatment of obesity

WINES

Wine has been defined as a beverage produced from the juice of the grape by fermentation and some may prefer to add the saving clause or with such additions as are believed to improve its keeping qualities ' From time immemorial wine has been extolled by poets, æsthetes gastronomes and others, and it has acquired a mythology, not altogether dead in these more materialistic days The term has been extended to fermentation products of more humble fruits of the earth than grapes e g apples, pears, cowslip and dandelion blossoms and even the maligned parsnip The characteristics of all these beverages are a beautiful colour, clarity, high concentration of alcohol when compared with beer, and a pleasant, though acquired taste

It must be confessed however, that the favourite drinks of the northern peoples of Europe are the fiery distillates from fermented grain products and the much less potent ales and beers Wine is intermediate between spirits and beer in the amount of alcohol it contains Wine is the normal alcoholic beverage of the countries where viticulture is possible, but in Great Britain the drinking of wine is restricted to the upper classes with the exception, perhaps, of port which is, or used to be, taken medicinally by the working classes often under the impression that it is non alcoholic Wine achieves a *succes d estime* in this country and is not the drink of the generality The attitude of the richer classes may be gauged by the importation of Algerian wine to be sold at the price of 8*s* 6*d* a bottle after the Germans were cleared out of North Africa The dietitian would have preferred, if it had been possible, the importation of olive oil

Twice within this century the wine producing countries of Europe, with the exception of Spain and Portugal, have been ravaged by war and it may be doubted whether in this generation the wine trade can fully recover in France, the valleys of the Moselle and Rhine, Sicily Italy and Greece

We propose to cut down the space devoted in previous editions to wine and restrict ourselves to a general statement of the sources, methods of production and analyses of wine

The quality of wine depends very much upon the variety of the grape the soil upon which it is grown the mode in which it is cultivated, and the climatic conditions of particular years The juice is obtained by crushing the grapes, treading being the method

often employed in order to avoid squeezing the stalks and stones too much and so extracting undesirable ingredients such as tannin

The chief *chemical constituents of the juice* are sugar nitrogenous matters, tannin and acids such as acetic lactic malic and tartaric acids The sugar is a mixture of grape sugar, or glucose and fruit-sugar or fructose in the proportion of about three parts of the former to one of the latter

The relative amount of nitrogenous matter and sugar in the juice has much influence on the character of the wine produced The yeast lives upon the nitrogenous matter and splits up the sugar, with the formation of alcohol and other products If there is but little sugar and much nitrogenous matter present the yeast can go on growing until all the sugar is split up The wine will then be " dry , and of an acid taste Such a wine is hock. If on the other hand, the sugar is out of all proportion to the nitrogenous substances in the juice a limit is set to the growth of the yeast and some sugar will be left in the wine, which will then taste sweet Should however, the sugar and nitrogenous matter be present in more equal amount the wine will retain some of both, and though not sweet will not have a distinctly acid flavour either, and will be of full body' It must be remembered moreover that no matter how much nitrogenous substance and sugar the juice may contain the production of alcohol cannot go on indefinitely for the accumulated alcohol ultimately ends by paralysing the yeast This takes place when the proportion of alcohol in the fermenting liquid has reached about 16 per cent by volume Hence it is that a ' natural ' wine can never contain more alcohol than this indeed there is rarely so much sugar present in the juice as to allow of its containing so much If a wine contains more than 16 per cent of alcohol by volume we may be sure that spirit has been added to it artificially, that is to say, it has been "fortified Sherry and port as sold in this country are always fortified wines, claret and hock, on the other hand are 'natural wines

The *colour* of red wines is due to a pigment contained in the skins of the grapes which is turned red by the acids of the juice As the skins are left in the vat in making such wines the alcohol which is produced gradually dissolves out this pigment and so the wine acquires its red or purple tint The colour of the white or brown wines is mainly due to the oxidation of tannic acid in the cask

The *yeast* which adheres to the skin of the grape and which is responsible for the fermentation of wine is different from the yeast which produces the fermentation of malt liquors or spirits Further we now know that the characteristic qualities of different wines are due in some measure at least to the fact that they are produced

by different species of yeasts Thus, the yeast concerned in producing hock is different from that which produces claret, and by growing a hock yeast on a claret ' must ' a wine is made which is as it were a cross between claret and hock and has some of the distinctive characters of both The *rancio* flavour of sherry which is characteristic of it is due to the development of acetaldehyde and derivatives of acetaldehyde by the aerobic film producing yeasts used in the manufacture of sherry

The exact details of the process of fermenting grape juice, in order to produce wine from it vary considerably in different countries and localities, and little would be gained by attempting to describe them fully As a rule, the first fermentation lasts for from two to six weeks depending largely upon temperature and the wine is left upon the lees till the spring when it is siphoned off for storage Prior to being placed in the cask, it is ' racked by the addition of isinglass or white of egg much as beer is by " finings, ' in order to remove nitrogenous matters (which prevent the wine from keeping) and suspended impurities When clear, it is again " racked off from the deposit and stored in casks in the cellar

In the cask many very important changes take place to the occurrence of which the ultimate character of the wine is largely due For one thing, the alcoholic strength of the wine rises This is due to the fact that the water of the wine soaks into the wood more than the alcohol does and is lost by evaporation, so that the wine becomes more concentrated As the water so lost is replaced by the addition of more wine the increase in the proportion of alcohol is rendered all the greater In the cask, too, a partial oxidation of the tannic acid takes place This causes the white wines to become darker in colour, but has just the reverse effect upon the red wines, for the oxidized tannin unites with, and carries down, some of their pigment

The small quantity of yeast which always finds its way into the cask produces a slow secondary fermentation of the wine, which often lasts for years As a result of this, some of the remaining sugar is converted into alcohol, and in this way also the alcoholic strength of the wine is increased As the proportion of alcohol rises some of the ingredients of the wine such as tannin and bitartrate of potash become less soluble, and fall down in the form of a deposit During this time also some of the alcohol is oxidized into acetic acid and the formation of esters takes place The maximum quantity of these, however, is usually reached in about five years for the presence of water prevents the formation of esters continuing till all available acids are used up

After bottling the formation of esters still goes on, possibly

with the aid of micro-organisms but the alcoholic strength of the wine does not increase It is quite a mistake to suppose that wine which has been kept long in bottle is necessarily stronger than a younger wine The reverse is the truth, for the alcohol seems actually to diminish after the wine has been bottled some years It is also an error to suppose that wine goes on improving indefinitely Like all other organic things it is liable to decay by the slow processes of oxidation and few wines really improve after thirty years many indeed such as clarets are at their best long before this, and it is only a few of the stronger wines, such as sherry and madeira, which will stand keeping for fifty, or possibly even a hundred years

Constituents of Wine The following is a list of the principal constituents found in grape juice or must ' and in the wine produced from it

MUST CONTAINS	WINE CONTAINS
Water	Water
Glucose, Fructose } 10 to 30 per cent	Glucose
Malic and tartaric acids	Fructose
Nitrogenous substances	Alcohols (mainly ethyl alcohol but including small amounts of propyl butyl amyl and other higher alcohols) 5 to 22 per cent
Extractives and essential oils	Acids (mainly tartaric but also including formic acetic propionic lactic butyric malic, and succinic) 0 3 to 0 8 per cent
Inorganic material	Esters of the foregoing alcohols and acids
Tannins colouring matters and fatty substances from the skins and kernels	Aldehydes such as acetaldehyde and furfuraldehyde
	Glycerol
	Nitrogenous substances
	Extractives and essential oils
	Inorganic materials 0 15 to 0 5 per cent
	Tannins and colouring matter

It will be realized from this what a very complex fluid wine is It would serve no good purpose however to give an analysis of wines in detail for, after all the information which chemistry can give us about wines is of limited value It can tell us it is true something about those ingredients which have most influence upon health, but it cannot tell much about those volatile compounds to which the most highly prized qualities of wine such as flavour and bouquet are due and for which one chiefly pays

It will be evident from this that sugar can hardly ever be present in wine to a sufficient extent to be of influence as a *food* Even a sweet wine with 4 per cent of sugar will contain only about an ounce in a bottle or pretty much the same quantity as a bottle of ordinary lemonade As Anstie points out it is hardly possible to take in *more than* $\frac{1}{4}$ *to* $\frac{1}{2}$ oz of sugar daily in the form of wine without at the same time consuming so much alcohol as would produce intoxication

Esters These are produced by the interaction of the alcohols and acids contained in the wine They are very numerous as regards variety, as can readily be imagined when it is pointed out that a wine containing five different kinds of alcohol and five acids may contain twenty five esters Their actual amount, however, is always very small The highest proportion Dupré found was in a fifty year old madeira and even then there was only 1 part of ester in every 300 of wine

The esters of wine may be divided into two classes (1) volatile, (2) fixed The former are produced by volatile acids such as acetic, the latter by the fixed acids, such as tartaric The volatile esters predominate in natural wines, while most fortified wines contain the fixed esters in greater abundance To this rule, however, sherry and madeira seem to be exceptions, for they are often rich in the volatile class

Acetic ester is usually the most abundant volatile ester met with in wine, but old wines may contain traces of propyl, butyl, amyl, caproyl and caprylyl acetic esters as well

The esters—and especially the volatile ones—are of importance as imparting to wine much of its "bouquet," and a rough estimate of their richness in any particular wine can be made by noting the distance at which the bouquet can be smelt

Extractives usually make up the bulk of the solid matter in all wines, except such as are rich in sugar They consist chiefly of pectins and gums They contribute to the taste and 'body' of the wine

Glycerol is produced along with alcohol in the process of fermentation and is always present in wine and in sufficient amount to affect the taste It is usually said that it amounts to one fourteenth of the volume of the alcohol but that is not quite accurate for different yeasts seem to produce it in varying amount so that no definite ratio between glycerine and alcohol can be laid down

Tannin The tannin in wine is derived chiefly from the skins and stalks of the grapes used and is therefore abundant in red

wines Its nature is specific to wine and the tannin is referred to as œnotannin to distinguish it from the tannins of tea and of oak bark etc Tannin in wine decreases by oxidation on keeping and the more mature the wine the less tannin it contains and the less its astringency A glass of claret has about the same amount of tannin as there is in a cup of tea

Iron and other Inorganic Substances As wine has a reputation for blood manufacture it is perhaps reasonable to call attention to its content of iron and copper There may be as much iron as 2 5 milligrammes per 100 c c in both musts and wines and the normal figure for copper is from 0 25 to 2 milligrammes per litre Some musts have as much as 23 milligrammes per litre but they are from grapes which have been sprayed with copper sulphate When washed these grapes give a must with from 0·8 to 1 8 milligramme copper per litre

Varieties of Wine Perhaps the most important division of wines is into (1) natural and (2) fortified The ***natural wines***, as already explained are those in which fermentation has been allowed to go to its full limit—that is to say, until the process is arrested spontaneously either by exhaustion of all the sugar and nitrogenous matter in the grape juice or until sufficient alcohol has been produced to prevent the further growth of the yeast The latter consummation is reached when the fermenting juice contains 16 per cent of absolute alcohol *by volume* ***Fortified wines***, on the other hand are those in which the process of fermentation has been artificially arrested by the addition of alcohol[1] either as silent spirit brandy or some other concentrated form Fermentation being thus arrested before all the sugar has been broken up such wines are apt to be sweet and are of course, of comparatively high alcoholic strength

Natural wines on the contrary, are usually poor both in alcohol and sugar The natural wines also containing as they do a little acetic acid produced by prolonged fermentation are rich in volatile esters even in their youth, while the fortified wines though they may ultimately contain much ester, only arrive at such richness in their old age and the fixed esters, except in the case of sherry and madeira preponderate over the volatile

The principal natural wines are claret burgundy ' white wines (e g Graves) and hock and the Hungarian Italian Australian and South African wines The chief members of the fortified group are port sherry, madeira and marsala Greek wines are also usually fortified

[1] In the case of some fortified wines however e g sherry the alcohol is added after fermentation is complete

Claret (probably derived from "clairet," a thin "vin ordinaire")[1] is produced in the district of Medoc, the seaport of which is Bordeaux It is ■ pure natural wine containing 8 to 13 per cent of alcohol by volume, very little sugar (about ½ per cent), and a moderate amount of acids, acetic acid being always present It contains also a high proportion of volatile esters The best growths, or "crus," are Château Margaux, Lafitte, and Latour

Haut Brion is a red wine produced in the neighbouring district of the Gironde, and resembles a burgundy rather than ■ médoc *Sauternes* are white wines made in the same district, and usually contain a good deal of sugar, from the grapes being allowed to hang for a long time on the vines before they are picked The famous Château Yquem is the finest of all the white wines so produced

Burgundy resembles claret, but is richer in extractive matter, and has therefore more 'body" It is also of higher alcoholic strength and contains more natural glycerol and less tannin than any other fine red wine It is produced in the district of that name, the best part being that which stretches between Dijon and Chalon Beaujolais and Mâcon, though not really produced in Burgundy, are usually classed with those wines Ordinary burgundy is made from black grapes, but Chablis is a white burgundy produced from white grapes grown in the same district

Hocks derive their name from Hochheim on the right bank of the Maine With the exception of that produced at Assmannshausen they are all pale wines They have about the same alcoholic strength as claret and contain hardly any sugar, for which reason they are apt to seem rather acid Their acidity however, is not much higher than that of claret, and they contain almost no acetic acid They have the advantage of possessing a fine bouquet and extraordinary keeping qualities

COMPOSITION OF ITALIAN WINES

	Capri (White)	Falerno (White)	Chianti (Red)	Barolo (Red)	Egidio Vitali (Sparkling White)	Valtellina (Red)
Alcohol by weight	11 62	8 64	9 36	10 65	10 09	9 36
" volume	14 37	10 73	11 61	13 43	12 49	11 61
Tartaric acid	0 52	0 66	0 60	0 45	0 79	[illegible] 41
Acetic	0 31	0 13	0 18	0 25	0 26	0·29
Sugar	0 76	0 11	0 17	0 18	3 67	0 13

[1] Everywhere except in England claret is known as Bordeaux wine

Italian wines both white and red all belong to the "natural" class. As a rule they are of low alcoholic strength, but rather more acid and astringent than a light Bordeaux wine Their acidity is rather high The analyses[1] given represent the composition of some of the varieties more commonly sold in this country

Australian wines are full bodied natural wines containing rather more alcohol than most clarets They are chemically pure, and in recent years have improved very much in the finer characteristics of good wine, as the result of greater care in the cultivation of the grape

The term **sherry** is applied to all the white wines of Spain being derived from the town of Jerez which may be regarded as the capital of the sherry producing district As drunk in this country they are all fortified wines containing from 16 to 22 per cent of alcohol by volume A "natural" sherry is quite a possible product but is never imported into this country on account of its being deficient in 'keeping qualities Sherries are also all 'plastered' wines that is to say calcium sulphate is sprinkled on the grapes after they are first trodden, in the proportion usually of 2½ lb to every ton

The practice of ***plastering*** is one of great antiquity and was mentioned long ago by Pliny It was first adopted no doubt empirically, and the advantages of it are still far from being fully understood although all experienced sherry growers are of opinion that without its aid the production of a wine having the special characteristics of sherry is impossible It may be that it acts as a preservative against the "viscosity fungus' which is so much commoner in Southern than Northern wines (Thudichum)

The chief chemical effect of plastering is to decompose the bi tartrate of potash in the ' must ' with the production of insoluble calcium tartrate, potassium sulphate, and tartaric acid according to the following equation

$$2KHC_4H_4O_6 + CaSO_4 = K_2SO_4 + CaC_4H_4O_6 + H_2C_4H_4O_6$$

The phosphates are also thrown down

As the tartrate of calcium falls out it clarifies the wine carrying down with it nitrogenous matters and suspended impurities The tartaric acid produced renders the wine redder, and increases its free acidity, so facilitating the production of esters later on

There is introduced into the wine as the result of plastering 0 3 gramme of calcium sulphate per litre and 1 2 grammes of potassium sulphate much of it, probably in the acid form The potassium sulphate may cause sherry to be slightly laxative to

[1] *Lancet* (1899), 1, 241

some persons if freely drunk, and renders it also somewhat bitter, but it cannot be said to have any other bad effects It has been said that it may be productive of cirrhosis,[1] but of this there is no sufficient evidence and, indeed the employés in the Spanish bodegas are stated to drink as much as 10½ pints of light sherry daily, without suffering from any injurious effects

The amount of sugar in sherry varies from practically nil in the driest sorts up to 4 per cent in a very raisiny wine The acidity is lower than that of the natural wines already considered

Sherry develops in its old age a very large proportion of volatile esters—more probably, than any other alcoholic liquor, except a genuine cognac

Broadly speaking, there are two classes of sherries

1 "Fino, a light, pale delicate wine of Amontillado[2] or Manzanilla[3] type

2 'Oloroso," a sweeter, full bodied brown wine Intermediate between these is the class known as 'Palo Cortado'

The following is an analysis of examples of these[4]

COMPOSITION OF SHERRY

	Amontillado Per Cent	Oloroso Per Cent	Medium Per Cent
Solids	2 20	5 45	2 87
Sugar	0 215	1 03	0 65
Potassium bitartrate	0 08	0 26	0 13
Tartaric acid	*0 34*	*0 52*	*0 41*
Acetic	*0 12*	*0 20*	*0 10*
Ash	0 55	0 86	*0 70*
Potassium sulphate	0 52	0 76	0 65
Alcohol by weight	14 82	18 85	15 67
" " volume	18 25	23 10	19 28
Total esters	0 06	0 21	0 075

Pure sherry may be regarded as a genuine grape product for the substances added to it in manufacture are also derived from grapes Thus 'grape liquor' is used for sweetening and the same, slightly caramelized, for colouring The spirit added in *fortification is also* obtained by distilling fermented grape juice Sherry has the advantage over most wines that it can be drunk all through a meal and also that *it does not deteriorate after* decanting

[1] See later under cirrhosis

[2] Amontillado = À la Mantilla (a town near Cordova)

[3] From Manzanilla a town near Jerez

[4] *Lancet* (1898) 2, 1135 (Report of Commission on Sherry from which many of the statements in the above paragraphs are taken)

Port is the wine produced in the district of the Upper Douro, and takes its name from the town of Oporto The whole of the wine that reaches this country is fortified, containing from 16 to 22 per cent of alcohol by volume One of the chief peculiarities of port is the large amount of "extract" it contains which gives it a full body Its acidity is not great less indeed, than that of hock but it contains relatively more acetic than tartaric acid, for the latter is insoluble in the large amount of alcohol which port holds It possesses a good deal of tannin the stalks not being removed before fermentation but this diminishes with age though when young it is very rough and astringent It is sweeter than sherry containing from 2 to 6 per cent of sugar for it is fortified before fermentation is complete not after it, as sherry is Old port contains a large proportion of esters but, unlike sherry contains more fixed esters than volatile When mellowed it has an excellent flavour and bouquet, and retains only a moderate amount of fruitiness

Madeira is derived from the island of that name For a long time the ravages of the phylloxera stopped the production of the wine, but the industry has begun to revive The wine resembles sherry in its general characteristics and in the high proportion of volatile esters which it contains It is a fortified wine containing from 16 to 22 per cent of alcohol by volume

Marsala is a Sicilian wine also resembling sherry, but sweeter and containing a much lower proportion of volatile esters It is only slightly acid

Greek wines may be either natural or fortified, but usually contain only 10 to 16 per cent of alcohol by volume They are rich in volatile acids and are peculiar also, in containing some aldehyde They are often plastered Their chief defects are due to imperfections in the methods of manufacture

Champagne is the wine produced in the Champagne district of France the best varieties being obtained from the prefectures of Rheims and Epernay It is produced curiously enough chiefly from black grapes These are squeezed in a very powerful press and the first pressings used to produce the finest wines The character of the vintage in different years has also a very marked effect on the quality The expressed juice or "must" is allowed to stand for 12 hours in order to let all suspended matters fall out and is then drawn off into casks to undergo the first fermentation At this stage the different growths or "crus" are blended to form the special "cuvées" the finest of which are only produced from the best grapes The young wine is then bottled and left for two years to undergo the secondary fermentation The maintenance

in the "finished" product There is little to be said in their favour

Cider and Perry, derived from the apple and pear respectively, may be conveniently considered here for they are really to be regarded as wines, cider indeed, when first made in England in the thirteenth century, was always called 'wine"

The finest ***English cider*** is made in Devon, Hereford, Norfolk and Somerset The mid season fruit, which ripens in October, is best for the purpose It is gathered and allowed to mellow under cover for a fortnight and is then ground to a pulp the kernels being sometimes left out *The pulp is left in vats for 30 hours*, and is then pressed, and 100 gallons of the liquor run into a clean vat and left for some days till it clears It is then racked clarified with charcoal and strained through bags and the clear, bright liquid run into 100 gallon casks and bunged down Perry is made in a very similar way If a 'sparkling" beverage is desired fermentation is allowed to go on in bottle The composition of these beverages seems to vary within rather wide limits They are only mildly alcoholic, having 3 to 8 per cent by volume, or much the same proportion as beer The amount of sugar varies greatly In a dry cider it may be 1 or 1 5 per cent or less but in a sweet cider it may rise to 6 per cent or more They are moderately acid (0 1 to 0 6 per cent) the chief acid present being malic, lactic is also present but, unless sophisticated cider contains no tartaric acid The more acid varieties (0 6 per cent) will have an acidity equal to that of about 1 43 grammes of tartaric acid per tumblerful

A sample of genuine Devonshire home made cider which Hutchison examined had the following composition

Alcohol (by weight)	4 8 per cent
Solids	1 5 "
Total acidity	0 66 "
Volatile acidity	0 089 "

The following analyses are by Chapman [1]

	Total Solids	Alcohol (by Weight)	Calorie Value per Pint
Bottled cider	5 12	3 92	27[illegible]
Draught cider	4 31	3 20	228

The 'colic once associated with cider drinking, now a thing of the past was due to storage at an early stage of production in leaden receptacles The colic was a lead colic not a cider colic

[1] *Journ Inst Brew* (1932) February 38 2

Medicated wines are compounds the basis of which is port or sherry, to which has been added extract of beef, extract of malt peptone, pepsin, coca leaves cocaine cinchona, iron, or some other dietetic or medicinal substance A "beef and malt wine" may usually be regarded as containing about 1½ oz of extract of meat and 2 oz of malt extract in a pint of "detannated" port or sherry [1] For the medicinal wines there is no definite formula Of the "coca" wines some are made from coca leaves others from liquid extract of coca, and some from hydrochlorate of cocaine

The following table [2] shows the proportions of the chief ingredients present in some of these wines, the composition of the ordinary standard wines being given for comparison

Wine	Alcohol by Volume	Sugar by Weight	Meat Extract by Weight corresponding to Nitrogen Found	Pure Alcohol in a Wine glassful
	Per Cent	Per Cent	Per Cent	Fluid Drachms
Claret	9	0 25	—	1½
Hock	10	Trace	—	1½
Champagne (dry)	10 to 15	Trace to 2	—	1½ to 2
Sherry (dry)	18	0 2	—	3 to 3½
„ (brown)	23	1 0		
Port	20	2 to 6	—	3½
Wincarnis	19 6	18 2	1 2	3
Glendenning's	20 8	10 6	0 4	3½
Bivo	19 2	11 5	3 4	3

Such wines are of doubtful value It is better for an invalid to get beef or malt extract separately and take along with them if need be a definite quantity of sound wine of known antecedents

Medicated wines should in any case only be taken under medical supervision

Apéritifs are wines containing some bitter ingredient designed to promote appetite and are specially popular in France The basis of them is either a red wine, as in Dubonnet Byrrh and Rossi or a white wine as in French and Italian Vermouth and Cinzano The bitter constituent in Vermouth is derived partly from wormwood,

[1] The quantity of bouillon represented by a wineglassful of such a wine varies from about 4 tablespoonfuls to 1½ teaspoonfuls (1909) *Brit Med Journ* 1, 795

[2] *ibid*

As was said above, the amount of tannin in red wines rarely exceeds that in an equal amount of a well made cup of tea, so that we cannot imagine that it is either very deleterious to the normal person, useful to the diarrhoeic, or harmful to the constipated Incidentally we may call attention to the tabu against taking tea along with meat and the absence of tabu against the combination of red wine and meat Lay dietetics is full of such inconsistencies

Alcohol We have already discussed the pharmacological effects of alcohol, pointed out that it is a depressant and not a stimulant and that there has been a very marked decrease of the use of alcoholic drinks as medicines in hospital practice Its value, if used at all, is as a sedative The effect of any wine in this direction must depend upon its content of alcohol and as the "natural" wines have only half the alcohol present in fortified wines they presumably are less sedative

But wines cannot be regarded as mere mixtures of alcohol and water in different proportions For one thing dilution is of importance The more dilute the alcohol is, the more slowly it is absorbed and the less chance of an active amount reaching the central nervous system at one moment Moreover there is a possibility that the esters present in wines influence its pharmacological action There is a belief widely held that the reason why old wines and old spirits for that matter, are less harmful than younger and more fiery liquors is because they contain more of the volatile and fixed esters The whole subject is obscure and made further obscure by prejudice on the part both of the supporters of and the detractors of the consumption of alcohol

We think that the following may sum up moderate opinion on the use of wine in health

1 It is doubtful if the taking of wine can be defended on the grounds that it makes for health On the other hand there is little evidence that a moderate consumption of wine is deleterious to health

2 If wines are taken the light red and white natural wines are the wines for daily use by healthy adults

3 Half a bottle a day of a natural wine for the sedentary and a bottle a day for the vigorous and actively employed adult are reasonable allowances

4 These should be taken at and not apart from meal times

5 Fortified wines are best kept for special occasions

6 There is little evidence that wines are useful in disease

CHAPTER XVIII

PRINCIPLES OF FEEDING IN INFANCY AND CHILDHOOD

General Observations

Human young take an unconscionably long time to learn to eat without the help and supervision of their elders Compared with say, a calf or a lamb a baby seems incompetent in learning to feed himself and he takes many more months than other animals before he can be left to his own devices in selecting his food The fact is that a baby with his potentially large and complicated brain has to be born in a relatively immature state in order to get born at all He has in consequence to be protected carefully while his nervous system is reaching the degree of maturity normal to most other mammals at birth After that he has to be led to take a share in adult food by slow stages These two periods together occupy the first three years of his life Thereafter for a further decade or more he is still dependent on others to provide and to prepare his food This last phase does not concern us here for with certain modifications of quantity to allow for growth in addition to maintenance the diet of the older child does not differ from that of the grown man or woman

Though the time over which the special problems of infant nutrition apply lasts for as long as three years the principles involved are few and simple Unfortunately they tend to get overlaid by masses of detail Some examples are necessary but it is our purpose here to outline principles, minute instructions of the changes in feeding to be made month by month must be sought elsewhere if indeed it is felt that they cannot be filled in by the application of common sense to a few general rules

Infant feeding may be considered to fall into four stages though the first cannot claim strictly to come within this title

I During intra uterine life
II Suckling (from 0–9 months)
III Weaning (from 7–12 months)
IV Transition to adult food (from 1–3 years)

During Intra-uterine Life

Diet during pregnancy has already been discussed (see pages 263 *et seq*) Little need be added to what has already been said despite the fact that we are now considering the nutrition of the fœtus rather than that of the mother Their two interests are complementary If the fœtus does not find what he requires for his own growth available from his mother's food, he is uncommonly well adapted to abstract it from her tissues When, for instance a pregnant woman's diet does not contain sufficient calcium and phosphorus to form the bones of her unborn baby, these elements are taken from the mother's own skeleton to her detriment Other substances whether simple, such as iron or complex such as protein and fat, are similarly filched from the mother's stores if her food does not supply the necessary surplus for her parasitic offspring To preserve herself from these depredations the pregnant woman must increase her intake of fat, protein carbohydrate and mineral elements in the way which has already been set out Recent work in Canada [1] has emphasized and lent precision to this point In these observations supplements were made to the diets of some of the poorer women in Toronto during the later months of their pregnancies The remainder were observed as controls The additional food consisted of one and a half pints of milk an egg an ounce of cheese an orange and some tinned tomatoes daily, together with 2 000 units of vitamin D and some wheat germ oil There was a significant difference in the health of those who received the extra food They were delivered of their babies with less risk and they suffered fewer puerperal complications Moreover, they produced healthier babies It seems therefore that the fœtus is not a completely successful parasite Within limits he is nourished at the expense of his mother but if she can eat and absorb the food needed by both the resulting baby is better than otherwise would have been the case Clearly, too, the fœtus cannot take from the mother substances which she does not possess An anæmic woman is unlikely to provide her baby with an adequate store of iron with which to start life A healthy woman often cannot, without special food provide enough for twins Iron and other blood forming elements e g ascorbic acid *must* be readily available Similarly, the baby will be born without his proper store of fat soluble vitamins if these have not been plentiful in the

[1] Ebbs J H Scott W A Tisdall, F F Moyle W and Bell M (1942) *Canad Med Ass Journ* 46, 1 Ebbs J H Brown G Tisdall, F F, Moyle W and Bell, M (1942), *Canad Med Ass Journ* 46 6

mother s diet This applies specially to the last few weeks of the pregnancy during the time in which the fœtus is laying down a fairly considerable store of fat under his skin It seems probable that he combines his reserves of fat with his reserves of vitamins A and D A premature baby, lacking his subcutaneous fat at birth is liable to rickets at a much earlier age than a full term infant The evidence that vitamin A is stored during the same period is not so complete There is no doubt, however of the disadvantages to the baby such as defective teeth, which arise when the mother s food has lacked adequate quantities of vitamin A and D during her pregnancy Other neo natal defects can no doubt be traced to shortages in the maternal diet A deprivation of vitamin K is held by some to be responsible for hæmorrhagic disease in the newly born and large quantities of this vitamin are therefore given to the mother during the last few days before her delivery While there is no doubt that a deficiency of prothrombin can on occasion be found in the newly born it is by no means certain that this explains all the cases of neo natal hæmorrhagic disease A more satisfactory method of avoiding prothrombin shortage is to ensure a balanced diet for the mother throughout pregnancy and so avoid the necessity of giving large doses of vitamin K at its end In general it may be said that diet must be planned to supply both the mother s own needs and the rather special requirements of her prospective baby

Suckling

In an ideal world the advice to be given about food during lactation would be essentially the same as that for pregnancy Unfortunately not all sucklings are nursed at the breast and the subject becomes more complex Not only is it necessary to consider the food to be eaten and avoided by the nursing mother but the nourishment she gives the baby has also to be analysed in order that it may be imitated in the too frequent cases in which breast feeding is not practised

There are then, to be considered here three matters

(A) The diet of the nursing mother
(B) The composition of human milk
(C) Substitutes for human milk

Diet of the Nursing Mother If the diet is not sufficient to nourish both a woman and her breast fed baby the latter gets all that is available at the expense of the mother It was observed in the siege of Paris [1] and the observation has been repeated too

[1] 1870

often since, that women are able to continue nursing although almost starved to death Not that this is a state of affairs to be tolerated even from the point of view of the baby Ebbs[1] has shown clearly how much more likely are women, whose diet is adequate to carry through breast feeding than those whose food is insufficient His observations were made under conditions similar to those quoted on page 522 but on this occasion they were applied to the period after the children were born The additional food was given to the supplemented group during the first six weeks only of the infant's life Even so the difference in the rate of breast feeding between the two groups at the end of six months was striking, 24 per cent of the women on the poor diet were nursing their babies against the 39 per cent of the women on the supplemented diet The discrepancy was greater still the longer the extra food was given the figures at six weeks being poor diet 65 per cent supplemented diet 86 per cent At six months of age, the babies in the supplemented group were healthier and somewhat heavier than those in the poor diet group

It should in theory, be possible to be more precise about the additional needs of a lactating woman than is the case with the diet during pregnancy The actual amount of milk secreted by her can be measured its composition is known and in consequence the sum of the daily output as Calories fat, protein, etc, can be worked out There is not in fact any great advantage to be gained by a precise mathematical approach The nursing mother can utilize a wide range of foodstuffs for the secretion of milk carbohydrates can be used to build up fats in the milk, and the carbohydrates in the milk have in any case, to be specially elaborated A woman is much more likely to breast feed her baby successfully if she is enjoying and digesting food she likes than if she is made to adhere rigidly to some hypothetically correct regimen

An increased fluid intake is one of the nursing mother's most urgent requirements It stands to reason that if she is producing up to two pints of milk a day she will need to drink that much more fluid If she does not do so, she may use some of the water normally excreted by her intestines and become constipated through the decreased bulk of their contents or she may lower her output of milk Either result is unfortunate for in the first case she will resort to purgatives which likewise may diminish milk output

Much of the additional fluid intake may be taken in the form of water Some however, should be in the form of milk and of

[1] EBBS J H and KELLY H (1942) *Arch Dis Child* 17, 212

fruit juices Cow's milk supplies organic ingredients which need little reconstitution to be resecreted as human milk and it is an excellent source of the calcium, magnesium, sodium, potassium etc, which have similarly to be found To what limits the milk may be disguised as tea or coffee or the water disguised as beer will be the subject of a later paragraph Juice from oranges grapefruit or tomatoes will augment her intake of salts and will supply a large part of her requirements of vitamin C

After water perhaps the most urgent addition to the diet is first class protein The daily output of protein in the milk reaches a maximum of over 20 grammes or just under an ounce The extra intake to provide this must be greater in quantity as there is some wastage in the process of reconstituting the protein to the forms in which it appears in human milk Cow's milk can supply some of the surplus and the rest should be provided by additional eggs meat or fish If cheese is acceptable and readily digested, it can take the place of the extra meat or fish and so give some variety

No special steps are needed to add carbohydrate or fat as long as the nursing mother can satisfy her hunger with bread and potatoes The extra milk and the normal amount of butter in her food will supply much of the milk fat and the rest can be elaborated by her own tissues from carbohydrate

The basic additions to the average adequate diet to be made each day during the period of lactation may therefore be summarized as follows

One pint of water
One pint of cow's milk
Five ounces of fruit juice
Three ounces of meat or poultry or fish or two and a quarter ounces of cheese
One egg

While it is right to allow a lactating woman to select her diet for herself so long as the foregoing additions are incorporated care must be taken to ensure that her vitamin intake is adequate It has been shown [1] that an insufficient amount of vitamin D in the mother's diet even in a sunny climate may result in the development of rickets in her breast fed baby What is true of one fat soluble vitamin can certainly be applied to another The vitamin content of foods tends to vary with many factors When as is

[1] SABRY I A and FIKRI M M (193.) *Arch Dis Child* 10, 377

here the case, it is desirable to make sure of a more than normal intake of vitamins A and D, it is wiser not to rely on foods as a source but to give the vitamins as a supplement. In whatever form they are given, vitamins A and D should exceed each day 4,000 I U and 1200 I U respectively. The position in regard to water soluble vitamins is not so clear. Milk is a poor source of ascorbic acid in any case and it is wiser to give the supplement directly to the baby, rather than to hope that a high maternal intake will ensure a sufficient amount in the milk. The mother should be having 50 milligrammes ascorbic acid a day on her own account. If the baby is given his ascorbic acid direct there is no need materially to increase this amount. Information about the other vitamins in relation to breast milk is mainly of a negative kind. The infants of women who have a normal balanced diet, are not known to be short of the vitamin B complex while they are at the breast, and it is to be assumed that no additional precautions need be taken in this respect. Conversely a woman who is herself suffering from deficiency of this or other water soluble vitamins is unlikely to pass on in her milk a proper amount to her baby.

The inclusion or exclusion of alcohol in the diet of a nursing mother has from time to time been the subject of hot debate often supported by a variety of not very relevant arguments. The fact is that alcohol does not help lactation any more than in moderation it hinders it. Baumm and Illner,[1] as long ago as the last century showed that the daily addition of two or three pints of lager beer to an ordinary diet had no effect on the composition of the milk, and other observers have shown that as much as five glasses of port or champagne are similarly devoid of influence.[2] Physiologically, alcohol may be regarded as the nutritive equivalent of a certain amount of fat, and as fat in the diet is without favourable influence on the composition of the milk so, too is alcohol. The common prescription of stout for nursing mothers is thus devoid of scientific justification for the nutritive ingredients of stout are its alcohol and its dextrins and both of these are unable to improve the quality of the milk.

On the other hand the bad effects on the child which have been attributed to the taking of alcohol by the mother, are equally imaginary, the fear that alcohol will be excreted by the milk being groundless, unless, indeed, the mother indulge in it to the extent of producing intoxication. Distillation of the milk in the above experiments failed to show the presence of any alcohol in it at all.

[1] (1894) *Samml Klin Vortrage (Gynäk)* N F 105, 41

[2] Klingemann quoted by Cautley

Alcoholic liquors then, cannot directly affect the quality of the milk If, however, a little bitter beer or a glass of wine at meals increases the mother s appetite and her power of digesting ordinary food, then such an addition to her diet will improve her own nutrition and with it the amount of her milk

It has been found [1] on the other hand, that when coffee is taken by a nursing woman nearly 1 per cent of the caffeine in the beverage is excreted in the milk and presumably the same would be true of tea Whether this can have any injurious effect on the infant may, however be doubted. Besides caffeine, other substances taken by the mother may be excreted in her milk, not always without harm to the baby This applies particularly to drugs, with which we are not concerned here, though it may be noted in passing that many purgative mixtures contain materials which later give the baby diarrhoea. There are also foodstuffs, such as stewed fresh plums rhubarb, and boiled new potatoes which tend to have the same effect on some but not all babies Such articles of diet need not be avoided by a nursing mother unless it is apparent that in the case of her own baby they give rise to undesirable results

The Composition of Human Milk

A normal, healthy woman provides her baby with milk of the quality and in the quantity he needs for the first seven to nine months of his life Upon this assumption are based all the deductions which indicate the physiological requirements of a baby during this period If for any reason it is impossible for the baby to be nursed at the breast his best chance of survival depends on his being given food which imitates as nearly as possible both in amount and kind that with which he would otherwise have been provided To this end it is necessary to measure the amount of milk taken by healthy babies and to study the composition of the milk The following paragraphs are concerned with these matters but first a word of warning is desirable There are very great variations in individual cases The figures given are averages No two babies of the same weight take exactly the same amount of breast milk in a given period nor does one baby take identical amounts from day to day There is also a wide range in the com position of human milk some of the factors concerned in its variability will be referred to later No amount of averaging will make the quantities set out precisely right for any particular baby and for the same reason there is no purpose in worrying about the

[1] E Schily and R Wohinz *Arch f Gynak* (1928), 134, 201

last decimal places in analyses of human milk Much of the work has been repeated in recent years, but unless the newer studies reveal significant differences in the average results, the figures of earlier authorities are just as serviceable and they are in consequence quoted here

Amount of Milk required by the Infant daily One can arrive only indirectly at the amount of breast milk which a child should get at each meal and in the course of the day Arguments from the size of the stomach in infancy are not of much value for individual variations in the size of the stomach are very wide and its size after death is no certain criterion of its capacity during life Nor is the amount of milk in the breast a certain guide, for the child need not exhaust the breast at each meal A method which has been widely adopted is that of carefully weighing the child before and after each feed If carried out on a sufficiently large number of infants, this method affords a fairly trustworthy basis from which to arrive at the average quantities required at each age and it is by such a method that the table on the opposite page has been constructed

The table includes two sets of observations which were made some time ago and a third series of observations on the early neo natal period by Mackay [1] which is more recent This is of interest in that it demonstrates a very close similarity to the earlier figures put forward by Camerer Mackay in her paper gives her findings as Calories taken each day but supplies the factor for con verting these figures into ounces and cubic centimetres in which form, for simplicity, they appear in the table She also starts her reckoning from midnight of the day of the infant s birth—that is to say, from an average age of twelve hours In consequence her totals must be placed half way between the corresponding figures for the early days of life put forward by Camerer With these adjustments the two sets of observations made at some consider able interval apart are very consistent and tend to confirm the reliability of the other figures of these earlier workers

Two deductions can be made from this table First the amount of fluid taken by a healthy infant increases proportionately with his weight during the early months of his life The average weight of a baby at birth (and for the first week) is about 7 lb this is doubled at the age of four months and trebled at a year He takes when left to his own devices, between 2 and 2½ oz of breast milk for each pound of body weight at the age of a week, and a similar amount per pound body weight when he weighs twice as much at the age

[1] MACKAY H M M (1941) *Arch Dis Childh* 16, 166

Amount of Milk Required Daily

Period		Author					
		Camerer		Mackay		Feer	
		Quantity in 24 hours.					
		g	oz	c.c	oz	g	oz
Day	1st	30	1 1	76	2 7		
	2nd	130	4 2	200	7·0		
	3rd	210	8 6	313	10 5		
	4th	290	10 1	374	13 1		
	5th	330	11 8	416	14 6		
	6th	365	13·0	439	15 4		
	7th	400	14 3	451	15 8	291	10 4
Week	Mid 2nd	450	16 1	466	16 3		
	2nd	500	17 8			549	14 6
	3rd	497	17 8			590	21 1
	4th	582	20 8			652	23 3
	5th	653	23 3			687	24 5
	6th	734	26 2				
	7th	780	27 9			804	28 7
	8th	803	28 7			804	28 7
	9th	817	29 2			815	29 1
	10th	850	30 3				
	11th	764	27 3				
	12th	767	27 4			828	29 6
	13th	819	29 2			852	30 4
	14th	829	29 6				
	15th	838	29 9				
	16th	843	30 1			893	31 9
	17th	851	30 4			902	32 2
	18th	875	31 3				
	19th	872	31 2				
	20th	820	29 3			947	33 8
	21st	862	30 8			956	34 1
	22nd	848	30 2				
	23rd						
	24th					980	35 0

of four months Thereafter as his gain in weight slows down, his rate of increased consumption decreases *pari passu* If the fluid requirements of a baby in the early months of life have to be calculated, it is wise to take the upper limit of normality and give him, daily, 2½ oz for each pound of body weight Secondly, the observations set out in the table indicate the Calorie requirements of a healthy baby Breast milk has a somewhat variable food value with a mean of about 19 Calories to the ounce For simplicity in reckoning both human and cow's milk are commonly computed to be rather richer than this at 20 Calories to the ounce Using the simplified factor it will be seen that the healthy infant takes between 40 and 50 Calories for each pound of body weight daily during these early months When his food has to be prepared artificially it is wiser to accept the higher figure and to offer him 50 Calories a pound a day during the first four months of rapid growth the requirements then diminish to 45 and then 40 Calories during the latter part of the suckling period

Obviously these data must not be applied too rigidly to any given child for healthy infants of a few weeks may take as much milk as feebler ones whose age is counted by months On the other hand wasted infants tend to have a higher rate of metabolism than normal babies of the same age, they are as it were extravagant machines and so may require relatively more food per unit of body weight than the normal Hence the rule of feeding an underweight infant according to the expected weight for its age rather than according to its actual weight Pritchard has also pointed out that the amount of food required by an infant is greatly influenced by such stimuli to metabolism as exposure to air and light

Analysis of human milk shows that it contains water protein, a small amount of non protein nitrogenous substances, fat, carbohydrate and a variety of mineral elements which are in part linked with the organic constituents and in part in solution The amount of each of these substances present in different samples of breast milk varies within rather wide limits Some of the factors contributing to this variation will be mentioned later It is impossible therefore to give a table of constituents which will be true of every sample of human milk The average figures themselves subdivided for the different stages of lactation, set out by Holt Courtenay and Fales [1] provide as good an account of the composition of human milk as any others They are as follows

[1] Holt L E Courtenay A M and Fales H L (1915) *Am Journ Dis Child* 10 229

CONSTITUENTS OF HUMAN MILK
(from Holt, Courtney and Fales)

	Protein Per Cent	Fat Per Cent	Carbohydrate Per Cent.	Mineral Elements Per Cent.
Colostrum	2·2[illegible]	2·83	7·[illegible]9	0·3077
Transitional	1·[illegible]6	4·37	7·74	0·2407
Mature	1·15	3·26	7·50	0·2062
Late	1·07	3·16	7·47	0·1078

It has been suggested that the figures for carbohydrate in this table are higher than are commonly found in this country and, for comparison, another series given by Davies[1] is added

CONSTITUENTS OF HUMAN MILK (from W. L. Davies)

	Protein Per Cent.	Fat Per Cent.	Carbohydrate Per Cent	Mineral Elements Per Cent
Early	2·14	3·76	6·29	0·31
Mature	2·01	3·74	6·37	—
Late	1·30	3·30	6·80	0·2

The similarity in these two sets of observations is much more striking than their divergence and the two together can reasonably be taken as representative of the present state of knowledge in this matter

The *proteins* which constitute between them from 1 to [illegible] per cent of human milk are lactalbumin, caseinogen and lact globulin. The last is present in very small amounts except at the very onset of lactation. It has the same qualities as the globulin present in the blood serum and represents such a small fraction of the protein in true milk, as opposed to colostrum, that it can be dismissed from further consideration here

A knowledge of the relative quantities of the other two proteins lactalbumin and caseinogen is of some importance, especially when it becomes necessary to adapt cow's milk for the use of young babies. In human milk the lactalbumin accounts for about two thirds of the protein present as the following table shows

[1] DAVIES, W. L. (1939) *The Chemistry of Milk* 2nd edn London

DISTRIBUTION OF LACTALBUMIN AND CASEINOGEN IN HUMAN MILK

Source	Total Protein Per Cent	Lactalbumin Per Cent	Caseinogen
Holt, Courtenay and Fales [1]	1 15	0 72	0 43
" "	1 07	0 75	0 32
Plimmer and Lowndes [2]	1 00	0 68	0 32

The ratio of lactalbumin to caseinogen of approximately 2 1 seems well established and must be regarded as representing the requirements of young babies despite the fact that some analyses of human milk report quantities much nearer equality

So much for the distribution of proteins in breast milk In addition, attention should be directed towards the amino acids from which these proteins are built up Such knowledge is required for two reasons First, the amino acids found to be present are *prima facie* those essential for a baby's proper growth No prolonged period of feeding with a substitute for human milk can be expected to be successful unless the baby is given during that time the amino acids to which his protein metabolism is adapted This point has to be borne in mind especially when considering some of the products put on the market for the consumption of ailing infants Secondly there is increasing evidence that certain amino acids are essential for the protection of tissues as well as for their growth The work on methionine [3] as an agent in minimizing liver damage illustrates this point (p 69) A table of the principal amino acids in human milk compared with those in cow s milk will be found on page 545 It shows that on this particular score cow s milk is a reasonable substitute The two columns together provide a yardstick against which other reputed infant foods can be measured

There are other substances in woman s milk besides the proteins which contain nitrogen This non protein fraction of the nitrogen is large and represents between a fifth and a quarter of the total nitrogen present in the milk (24 5 per cent Plimmer and Lowndes [4] 15–20 per cent Rietschel [5]) For the most part however it does

[1] HOLT L E COURTENAY A, and FALES H L *loc cit*

[2] PLIMMER R H A and LOWNDES J (1937) *Biochem Journ* 31, 1751

[3] HIMSWORTH H P and GLYNN L E (1944) *J Clin Invest* E, 133

[4] PLIMMER R H A and LOWNDES J *loc cit*

[5] RIETSCHEL, H (1906) *Jahrb F Kinderh* 64, 125

not contribute to the nutritive value of the milk The bulk of the non protein nitrogen is present as urea Some about one tenth part according to Courtenay and Brown[1] appears as free amino acids Whatever their significance these substances containing the non protein fraction of the nitrogen play no great part in the nourishment of the baby, nor is it necessary to take them into account when a substitute for breast milk has to be found

The *fat* in breast milk is suspended in a fine emulsion It differs but little either in quantity or quality from that found in cow s milk It accounts for almost half the food value of the milk and in the various analyses of milk shows smaller variations than most of the other constituents The milk in the earlier stages of lactation is slightly richer in fat than that which comes later Even when the baby is growing most rapidly in the first two months of his life the proportion of fat in breast milk does not often exceed 4 per cent, a figure which falls later to just under 3½ per cent when the rate of growth declines These figures are important and indicate an upper limit of fat requirements If this is exceeded diarrhœa and vomiting are likely to follow On the other hand a baby cannot thrive if his food contains materially less fat over a long period

The full needs of the body for heat will fall upon the combustion of fat and carbohydrate and as fat is a more compact fuel than carbohydrate and the capacity of the alimentary tract of the young is small it is to be expected that the percentage of Calories to be obtained from the fat will be high Moreover, the intensity of metabolism in young growing tissue is some 25–50 per cent greater than that of adult tissue This excess production of heat must come from the combustion of fat and carbohydrate In addition to maintaining the body temperature fat is used during the period of rapid growth actually as a tissue producer The infant lays down fat and substances derived from fat in its fat depots in the marrow of its bones and in its nervous tissues Lastly, fat is an essential vehicle of vitamin A which ensures the health of epithelial tissues and nerves and of vitamin D, which prevents rickets

Carbohydrate is present in breast milk as lactose In addition there is a variable minute amount of dextrose The quantity of carbohydrate 6 5–7 5 per cent is high compared with the milk of many other mammals The discordance of the analysis as recorded in this country and in North America has already been

[1] COURTENAY A M and BROWN A (1930) *Arch Dis Childh* 5, 36

referred to on p 531 As further evidence of the discrepancy Myers[1] found an average of 6 0 per cent sugar in the milk of 86 women on this side of the Atlantic while Denis and Talbot[2] record 7 1 per cent as the mean lactose content in 60 samples on the other The difference is not important It seems reasonable to assume that British babies will do well with milk containing 6 per cent of carbohydrate, but that this amount can safely be increased to 7 per cent Beyond this there is danger On the whole carbohydrates are the ingredient of the diet which is least likely to be *represented in too small amount* On the contrary there is a much greater danger of supplying them in excess or of making them a substitute for fat An infant who is the victim of such an error may be plump enough but his muscles are flabby, its skin pale and its bones often rickety It is the false appearance of good nutrition which such infants often possess that is apt to deceive the uninitiated and such children have been known to receive prizes at baby shows It must be remembered too that *carbohydrates especially* when given in excess and in *unsuitable forms* are prone to undergo fermentation in the stomach and intestine of the infant, whereby acids and flatulence are produced causing griping and diarrhœa

The *inorganic ingredients* of breast milk are as important as any of the others During the early months of life the skeleton is growing at a rate never approached at any later time, large quantities of calcium and phosphorus are required for this alone In addition muscles blood and nervous tissue to mention only a few, need salts as well as organic matter for their proper growth Human milk provides these elements for a baby in the proportions in which they are needed just as cow s milk does for a calf or mare s milk for a foal The mineral requirements are peculiar to each kind depending on the rate of growth and other factors Consequently it is important to know what is naturally supplied to a baby so that the same proportions may be imitated as nearly as possible when an *artificial substitute has to be provided* The total amount of minerals and mineral salts as represented by the ' mineral elements of breast milk falls between 0 2 and 0 3 gramme per cent Illustrations of typical findings appear in the following table

[1] MYERS H (1927) *Brit J Child Dis* 24, 249
[2] DENIS W and TALBOT F B (1919) *Am J Dis Child* 18, 93

MINERAL CONTENT OF HUMAN MILK

Source.	Mineral Elements gm per 100 gm.
Heubner [1]	0·20
Camerer and Söldner [2]	0·27
Holt *et al* [3]	0·31
" " "	0·24
"	0·21
	0·20
Davies [4]	0·31
	0·20

Holt Courtenay and Fales further demonstrate the proportions of calcium magnesium etc, which go to make up this inorganic residue

DISTRIBUTION OF ELEMENTS IN ASH OF HUMAN MILK
(grammes per 100 gm)

Stage of Lactation.	Total Ash Per Cent	CaO	MgO	P_2O_5	Na_2O	K_2O	Cl
Colostrum	2·83	0·0446	0·0101	0·0410	0·0453	0·0938	0·0568
Transitional	4·37	0·0400	0·0057	0·0404	0·0255	0·0709	0·0588
Mature	3·26	0·0458	0·0074	0·0346	0·0132	0·0609	0·0358
Late	3·16	0·0390	0·0070	0·0304	0·0195	0·0576	0·057[illegible]

This table gives a clear indication of the amounts of calcium phosphorus potassium and so forth normally afforded to a baby in the first few months of his life There is more to it however, than the bare figures suggest These elements must be offered in a form in which they are available for use One of the obvious merits of breast milk is that in this they are provided in the right quantities and in a readily assimilable form When human milk is not given to a young infant it is better to sacrifice an imitation of the precise quantities than to give the right amounts in a form in which they are useless Fortunately the milk of other mammals,

[1] HEUBNER (1899) *Zeit f Diät u Physik Therapie* 3, 1
[2] CAMERER and SÖLDNER (1896) *Zeit f Biolog* 33, 535
[3] HOLT E COURTENAY A M, and FALES H L *op cit*
[4] DAVIES W L *op cit*

although it may contain these inorganic matters in vastly different proportions, does provide them in a form in which they are of use

No indication has been given in the foregoing table of the iron content of human milk This is small in any case, about 0 006 gramme per cent It may be noted that even in this low concentration it is about three times as much as is found in cow s milk This deficiency can be a fertile source of trouble for those babies who are not fed at the breast

The importance of *water* to the infant will be evident when one recollects that more than three fourths of the whole body consists of it, and that it constitutes about four fifths of milk which is the natural diet of infancy Water has also local uses in the stomach and bowels, promoting as it does the processes of absorption and secretion One is too apt to forget that an infant may suffer from thirst as well as from hunger, and that water will allay the former better than milk The effect of a drink of cold water is certainly always worth trying if a child is suffering from evident but unexplained discomfort

Variations in the quantity and quality of the milk given by different women are considerable as indeed are they in the milk of the same woman at different times The figures which have been quoted here are the mean result of many observations and they do not give any idea of the range of findings from which they are derived It would not be misleading to suggest that this range is 50 per cent each way on the average recorded On the whole it is not a serious matter that an average figure is preferred to a range of figures The most important point that might be made by quoting a wider series of observations would be the adaptability of a baby to different quantities of the constituents of his food On the other hand mean figures give a much clearer indication of what must be arrived at when substitutes for human milk have to be found and for the most part they have been made use of here

Many factors share in producing the variations and brief mention must be made of some The table on p 529 demonstrates the increase in quantity of the milk and the tables on pp 531 and 536 the decrease in its quality with the age of the baby The increase in the quantity corresponds roughly with the baby s increase in weight As he gets a greater bulk of fluid, the food value of the milk itself per c c slowly decreases The diminution is effected for the most part by a decrease in the fat content, the carbohydrate and the protein are also involved though to a much smaller degree

Colostrum (table, p 531) is the fluid which is secreted by the

breasts before they start to elaborate true milk It is produced for only a very short period from about the second to the fourth day after the birth of the child and its importance in the present context is therefore not great The composition of colostrum, as will have been observed in the table differs materially from that of milk It contains much less fat but more protein and more inorganic matter The protein is different in quality from that of milk for it consists of a higher proportion of globulin Some authorities attribute considerable importance to the high globulin fraction of colostrum believing that it conveys from the mother to the baby in the earliest days of his life bodies which give him immunity to certain infections In humans this function of colostrum is not so great as it is in the case of mammals with a different type of placentation whose young acquire little immunity *in utero* For the present purposes the short period of secretion of colostrum may be regarded as a preparatory phase both for the baby and for the mother It is an important stage in itself but relatively plays a very small part in the baby s nutrition

Apart from colostrum the changes in milk with the progress of lactation present a pattern such as one would expect When the baby is small he receives little milk of a high food value as he grows he gets more milk whose concentration slowly diminishes

The influence of diet on the composition of milk has already been discussed (p 523 *et seq*) Little need be added here to the earlier conclusion that while women will continue to lactate even when starving they can produce milk of the optimum quality only so long as they are properly fed Conversely the effect or rather the almost complete absence of effect on the milk of over feeding was demonstrated by Baum and Illner [1] towards the end of the last century They found a small increase in the fat content when the diet was varied but taken in great abundance and a similar change with a high protein diet Otherwise their experiments which included starchy salty and very fluid diets produced no observable change in the milk This is not to say that a lactating woman can over eat with impunity It merely means that she would upset her digestion without in any way enriching her milk

Seeing that the composition of the milk is so little affected by diet one should not jump to the conclusion that if an infant is suffering from dyspepsia there is some error in the mother s food Other causes must be sought and one will almost invariably be found

Frequency of suckling has some influence on the composition of

[1] BAUM R and ILLNER (1894) *Samml Klin Vortrage* N F 105, 41

the milk The act of suckling serves as a stimulus to the breast, and if repeated at too short intervals the richness of the milk is increased Hence if a child is crying from indigestion an attempt to quieten him by frequent giving him the breast leads in the end to the production of a less digestible milk and so to an aggravation of the trouble

Variations dependent on individual differences in the mother or her child are of comparatively little importance It has been found that the milk of any given woman will show greater variations from day to day than the milk of different women on any one day Weak women, also seem to furnish as good a milk as those who are robust and strong, and the milk of women who have borne many children is but little poorer than that of those who are nursing their first infant Age also, has little influence for the milk of women approaching the climacteric has not been found inferior to that of mothers hardly out of their teens Illness, menstruation, pregnancy fever and even severe emotional disturbance are also almost entirely devoid of any appreciable effect on the composition of the milk The most striking fact about the composition of the milk, indeed, is its independence of outside influences

Physiological Requirements in the Diet of Infancy

Enough has now been said to allow us to draw some conclusions about the physiological requirements of a young baby These deductions are aided by the fact that the absorption of the constituents of human milk in the intestine of infants seems to be very complete Protein [1] is said to be absorbed to the extent of 99 per cent fat to 97 per cent and the inorganic materials to 90 per cent, while the sugar enters the blood in its entirety *Consequently* one may safely assume that very nearly all the breast milk taken is required and the whole of its constituents take part in the baby's metabolism

A healthy infant spends most of its time in sleeping and growing Its muscular efforts are confined to a little sucking, more or less crying and some kicking From this we might argue that the diet of an infant should contain relatively more of the tissue builders (proteins and mineral matters) and relatively less of the energy producers (fats and carbohydrates) than is found in the food of the adult *In point of fact* nature supplies in milk a food of which this is by no means true If we take the percentage of the total Calories provided by proteins as compared with those provided by fat and carbohydrate together we find that the figures are almost

[1] APPLEMAN (1881) *Deut Archiv f Klin Med*, 28, 437

identically the respective percentages provided by investigations into the diet of families in Great Britain[1] Caseinogen and lactalbumin supply about 10 per cent of the total Calories in human milk and in the diets of St Andrews Cardiff and Reading protein supplies 11·0 10 1 and 10 5 respectively There is naturally as close an agreement in the sums of the fat + carbohydrate figures Where the figures are not in agreement is in the percentages of Calories provided by fat and carbohydrate separately In milk the figures are fat 47 5 per cent carbohydrate 42 1 per cent In adult (or rather family) diets St Andrews fat, 35 4 per cent carbohydrate 53·6 per cent Cardiff fat 33 2 per cent, carbohydrate 56 7 per cent, Reading fat 32 1 per cent and carbohydrate 57·4 per cent

In other words the proportion of protein in the infant diet is about the same as that in the adult diet whereas the fat supplies an even larger percentage of the Calories than it does in the adult

But we have to remember that all the protein in the infants diet is first-class protein—protein of high biological value—whereas only a third to a half of the protein in the adult diet is such This consideration is of fundamental importance in the feeding of infants and children, especially in artificial feeding It does not matter therefore if the percentage of protein is comparatively low so long as it is protein of high biological value Further the protein is mainly used in the construction of new tissues and therefore will not give rise to that production of heat which we have learned to call the specific dynamic action of protein We thus see that the initial deduction is by no means so contrary to fact as it seems The infant does actually get more first class protein in proportion than the adult and needs heat producing foods to the same proportion as the adult because its metabolism is much more intense and the protein it lays down as tissue has no specific dynamic action

The constituents of the food of sucklings and adults can be compared in another way If we choose specific examples say a four months old baby and a ten stone man doing physical work we get a set of figures such as those set out in the following table The baby s weight at four months being 14 lb or just a tenth that of the man simplifies the comparison While the constitution of the man s diet has been selected in an arbitrary way it is a probable average sample and serves well enough The figures for the baby are derived from the tables set out earlier in the chapter

It will be seen that the baby gets nearly twice as much food for each pound of body weight as the adult The surplus is derived

[1] St Andrews CATHCART and MURRAY (1931) *Med Res Council Report* No 151 Cardiff and Reading (1932) *ibid* No 165

Comparison of the Constituents of an Adult's and a Suckling's Food

	Grammes daily				Excess of baby's over adult's per cent
	Total		Per Pound Body Weight		
	10 st Adult	14 lb Baby	10 st Adult	14 lb Baby	
Protein	80	10 35	0 57	0 74	30
Fat	110	29 34	0 79	2 10	166
Carbohydrate	450	58 50	3 2	4 18	31
Calories	3192	550	22 6	39 3	74 2

largely from fat, and to a much less extent equally from protein and carbohydrate. The difference is even greater than the figures make it appear, for the baby absorbs a higher proportion of his food than the adult; furthermore, the proteins of his milk are of a greater biological value than those in a mixed diet.

CHAPTER XIX

THE PRINCIPLES OF FEEDING IN INFANCY AND CHILDHOOD (*continued*)

SUBSTITUTES FOR HUMAN MILK

In the last chapter we learnt that the physiological peculiarities of infancy demand that the diet during that period of life should be relatively rich in first-class protein and mineral matter, and especially so in fat A consideration of the chemical composition of human milk showed how well adapted it is to meet these demands, while a computation of the amount of it which infants consume at different ages enabled us to form some idea of the quantity of each nutritive ingredient actually required at each period of infancy Further investigation taught us that human milk is easily disposed of by the infant's stomach, is absorbed very completely in the intestine is a fluid of high nutritive value and therefore eminently adapted for the requirements of the child

These results of scientific investigation have long been anticipated by experience and both unite to emphasize the inestimable value to the infant during the first nine months at least of its life of a dietary of human milk Unfortunately, however the mother is often unable or unwilling to suckle her infant and one has to find some substitute for the natural supply A wet nurse is of course from the infant's point of view the best alternative but one need hardly say that this mode of feeding is open to considerable practical disadvantages The use of preserved human milk is similarly attended with difficulties When any surplus supply is available breast milk can be kept for many months either by a process of repeated pasteurization followed by refrigeration or by freezing it speedily on carbon dioxide snow and storing it at a temperature below its freezing point But the amounts available are meagre and the process so specialized that such preserved human milk can be used only in the direst emergencies It cannot be looked upon as a practicable alternative means of infant nutrition The milk of other animals must therefore be considered The following table exhibits the approximate composition of the milk

of some of the commoner domestic animals compared with that of human milk

COMPOSITION OF THE MILK OF DIFFERENT ANIMALS [1]

	Protein	Fat	Lactose	Ash
Human	1 3 –2 13	3 30–3 76	6 80–6 29	0 20–0 31
Cow	3 40	3 75	4 75	0 75
Goat	3 67–4 22	4 33–7 57	3 61–4 96	0 84
Mare	1 84–2 05	1 14–1 17	5 77–6 89	0 30–0 36
Ass	1 85–2 04	1 37–1 50	6 09–6 19	0 49

It will be observed that none of these is identical with human milk

This is not surprising for the composition of a milk, especially as regards its proteins and mineral constituents, seems to depend upon the rate of growth of the animal for which it is intended The faster a young animal grows the richer is the mother s milk in these two ingredients [2] This fact is brought out very strikingly in the following table

	Time by which Weight is Doubled	100 Parts Milk contain			
		Protein	Mineral elements	Calcium.	Phosphoric Acid.
Human	180 days	1 0	0 2	0 032	0 047
Horse	60	2 0	0 4	0 124	0 131
Ox	47	3 5	0 7	0 160	0 197
Goat	19	4 3	0 8	0 210	0 322
Pig	18	5 9	—	—	—
Sheep	10 „	6 5	0 9	0 272	0 412
Cat	9½ „	7 0	1 0	—	—
Dog	8	7 3	1 3	0 453	0 493
Rabbit	7	10 4	2 4	0 891	0 996

From time immemorial mankind has tried diverse experiments in the use of milk of other animals as food for their own young If report be true Romulus and Remus were by no means alone among the ancients in sucking the dugs of most unlikely foster mothers To this day the milk of mares, asses and ewes is a staple part of the food of many races of mankind, and is therefore the

[1] DAVIES (1939) *The Chemistry of Milk* Chapman & Hall
[2] HEUBNER (1899) *Zeit f Diät und Physik Therapie* 3, 1

first resort for their young as a substitute for breast milk. In this country, however, cow's milk and, to a much smaller extent, goat's milk are normally the only possible alternatives to a baby's proper food. Goat's milk has the same disadvantages as cow's milk only more so, since it is more concentrated than cow's milk, and lacks the merit of being everywhere available. If for any reason it is desirable to use goat's milk rather than cow's milk as a substitute for breast feeding, the same rules for modification apply except that the dilution must be greater in proportion to its higher protein, fat and mineral content. The rest of this chapter is devoted to the adaptation of cow's milk to the use of the very young baby. The fact that this occupies a number of pages should not be regarded as an indication that cow's milk can ever adequately take the place of human milk. There are occasions when its use is inevitable. Death or insanity of the mother are among the few compelling reasons for the cessation of breast feeding. No claim is made that any alternative is so good that its use is warranted as a matter of personal convenience.

Chemical Differences between Human and Cow's Milk

(a) Quantitative Differences. Taking the average results of a great number of observations on the general chemical composition of the two milks, one may compare them thus:

	Human Milk		Cow's Milk	
Water	87 to 88 per cent		87 to 88 per cent	
Protein	1	2	3	4
Fat	3	4	3½	4½
Sugar	6	7	4	5
Mineral salts	0.1	0.2	0.7	
Reaction	Alkaline		Acid	

One sees that while the total amount of solids in the two kinds of milk is about the same, yet the relative proportions of the different constituents in the two cases are very different. Cow's milk is the richer in protein, mineral matter and (to a less degree) in fat; human milk excels in sugar. The superiority of cow's milk in the building materials is no doubt due to the more rapid rate of growth of the calf than of the infant, but the excess of carbohydrate in human milk is rather surprising when one compares the relative muscular activities of the calf and the baby. It is difficult to explain this difference save on the grounds of the comparatively greater need of the infant for galactose in building up the central nervous system.

The proportion of lecithin is also relatively much greater in human

than in cow's milk there being 3 05 parts of lecithin to every 100 parts of protein in the former, and only 1 40 to 100 of protein in the latter This is probably to be attributed to the relatively greater weight of the brain in the child than in the calf [1]

(b) **Qualitative Differences** On more closely examining cow's milk, one finds that the differences in kind between its principal ingredients and those of human milk are even greater than the differences in the relative amounts Sugar, indeed is the only ingredient which is identical in kind in the two milks, the nitrogenous matters, the fat and the mineral salts must be compared separately in each

Nitrogenous Matters We have already seen (p 530) that human milk includes a considerable proportion of non protein nitrogen Cow's milk contains considerably less of these

The proteins of milk are of three kinds, caseinogen albumin and globulin The quantity of globulin in the mature milk both of women and cows is so small that it may be neglected The proportions of caseinogen and lactalbumin differ with the samples of milk selected but it is constantly found that cow's milk contains relatively much more caseinogen and human milk more albumin Davies [2] gives average figures of 2 7 per cent caseinogen and 0 5 per cent albumin in cow's milk, that is to say, rather more than five times as much casein as albumin In human milk (p 532) we have seen that there is nearly twice as much lactalbumin as caseinogen (0 72 to 0 43 gramme) To put the matter another way, one may say that the caseinogen content of cow's milk is eight times as great and the lactalbumin content only two thirds as great as that found in breast milk It is believed that the food value of caseinogen as a protein is less than that of lactalbumin If this is true, then cow's milk cannot be considered to have an advantage over breast milk strictly in proportion to its higher protein content The difference between the two in respect of the biological value of their proteins is however, insignificant in comparison to the disadvantages presented by the physical properties of caseinogen in excess as a baby's food Caseinogen behaves in a way entirely different from lactalbumin in the infant's stomach In the presence of the gastric secretions the proteins of cow's milk form a much tougher clot than those of human milk Some part of them are wasted because the clot is never broken up completely and part

[1] BUROW 'Der Lecithingehalt der Milch und seine Abhängigkeit von relativen Hirngewicht des Säuglings (1900) *Zeit f Physiolog Chemie* 30, 495

[2] DAVIES W L *op cit*

of the protein is excreted unabsorbed in the stools In addition the tough clot may, by mechanical irritation, give rise to most undesirable digestive disturbances

Other properties of the proteins of the two milks are beginning to assume increasing significance namely the relative proportions of the amino acids from which they are built up Reference has already been made (pp 69 and 70) to methionine as a liver protecting substance Other amino acids have also been suggested either as remedies for disorders or as essentials in certain minimum quantities for proper growth and development Knowledge in these matters is not yet complete It is desirable, nevertheless to have in mind the relative proportions of the amino acids in cow s milk and human milk The figures given by Plimmer and Lowndes [1] on this subject are set out in the following table

AMINO ACID CONTENT OF MILK (grammes per 100 ml)
(Plimmer and Lowndes)

	Cow s Milk			Human Milk.		
	Caseinogen [illegible]	Lactalbumin 0 71	Total [illegible]	Caseinogen 0 32	Lactalbumin 0 68	Total 1·00
Arginine	0·055	0·028	0 113	0 012	0·034	0 046
Histidine	0·038	0·013	0 051	0 005	0 011	0·016
Lysine	0 140	0 044	0 184	0 017	0·045	0 062
Tryptophane	0·031	0 013	0 014	0 003	0 017	0 020
Tyrosine	0 132	0 026	0 158	0 017	0 030	0 047
Cystine	0 008	0·024	0 032	0 002	0 030	0 032
Methionine	0 066	0 016	0 082	0 009	0 009	0 018

There are surprising variations not only in the total amounts of the amino acids in the two milks but also in the proportions found in the two caseinogens and lactalbumins All the amino acids are represented in both milks and they are without exception present in greater quantities in cow s milk In fact, if milk were diluted with an equal quantity of water, they would still all be present in the resulting mixture in larger amounts than in undiluted breast milk save for cystine alone It does appear therefore that there is a very wide margin of safety in the use of cow s milk even if diluted as a source of supply of all the essential amino

[1] PLIMMER R H A and LOWNDES J (1937) *Biochem Journ*, 31 1757

acids Any harm to very young babies is to be expected from their abundance in cow s milk rather than their deficiency

Fat The fat of human milk contains more oleic acid and has consequently a lower melting point and is more easily digested than the fat in cow s milk This greater digestibility of the fat of human milk is increased by the fact that it is present in a much finer state of division than the fat droplets in cow's milk In practice these differences are not material

The *inorganic materials* in the two forms of milk also show important differences Not only are calcium and phosphorus both present in much smaller amount in human milk, but there are important differences in the form in which the phosphorus occurs in the two cases [1] In its high proportion of organic phosphorus human milk recalls the chemical peculiarities of plant embryos or the yolk of egg Considering the great importance of phosphorus in the nutrition of the infant and the fact that organic combinations of it may be more easily assimilated than its inorganic salts one must admit that the differences between human and cow s milk just pointed out are not to be lightly disregarded

There is moreover, more iron in human milk than in cow's milk even if the latter does take up some iron from the containers into which it is milked The lowest figure for iron in human milk is higher than the highest in cow's milk

In the light of these facts, regarding the profound qualitative differences in chemical composition between human and cow s milk, one must conclude that it is impossible so to modify the latter that it shall be identical with the former In other words a truly humanized " cow's milk is a chemical impossibility

Comparative Digestibility of Cow's and Human Milk

It is a familiar fact that most young infants have much greater difficulty in digesting cow's milk than that of their own mother Part of the difficulty arises from the difference in the quality of the milks which has been referred to Indeed it may be considered that the milk of one kind of mammal can never be wholly suitable for the young of another kind Yet a minor part of the trouble is of a physical nature in that cow s milk forms a much denser clot in the stomach than human milk

The greater density of the clot is due—(1) to the absolutely larger proportion of caseinogen in cow s milk and probably also to

[1] Hess and Helman, (1925) *J Biol Chem* 64 781 find that the phosphatide content of cow s milk is twice that of human and the total phosphorus four times as great

those chemical differences between cow's and human caseinogen already mentioned, (2) to the smaller proportion of fat and soluble albumin relative to the caseinogen which characterizes cow's milk —the soluble albumin and fat of human milk seem to act mechanically in producing a loose clot, (3) to the fact that cow's milk contains more calcium and acid than human milk, and the density of the clot depends very much on the proportions of these two constituents

For all these reasons cow's milk tends to form a dense, retracted clot in the stomach while the clot of human milk is loose, friable, and easily broken up

In the intestine there is much less difference in behaviour between the two milks The stools of infants fed on cow's milk are richer in mineral matters than those of breast fed children, but then, cow's milk is richer in minerals than human A higher proportion of the fat of cow's milk also escapes digestion than is the case with human milk, and probably also a somewhat greater proportion of protein, certainly the fæces of bottle fed babies contain more nitrogen than those of infants reared at the breast

Infant Feeding with Cow's Milk

It will be agreed that if a substitute for human milk has to be provided for a young baby, cow's milk or a food derived from cow's milk is the commonest practicable alternative In the preceding section the differences between human and cow's milk have been considered Any modification made to the latter to render it suitable for babies must be made with these differences in mind

Before discussing the means of adapting cow's milk it is necessary to set down certain general rules that must be fulfilled whatever form of substitute feeding is adopted

1 The food must be of *sufficient caloric value* During the first four months of life a baby needs about 50 calories for each pound of body weight a day From five to nine months its requirements are less and after the age of nine months these fall below 40 calories a pound body weight a day It is necessary, therefore to know the caloric value of whatever is given Each ounce of cow's milk gives 20 Calories and an ounce of sugar 116 calories From these figures the food value of most modifications of cow's milk can be worked out though when the dried milks are used it is simpler to ascertain their caloric value from the manufacturers This should be stated on the labels on the tins

2 Along with its food a baby must be given *enough fluid* Observation of breast fed babies shows that they take about $2\frac{1}{2}$ oz

of fluid for each pound of body weight in the day, and this figure should be aimed at when they are "artificially" fed

3 The *quantity* given *at each feed* must be such that it will satisfy the infant without over filling his stomach It is possible to arrive at the quantity of the individual feeds by dividing the baby's total requirements for the day by the number of feeds to be given The table on p 529 gives an indication of the daily quantities required at different ages or they can be calculated on the basis set out in the last paragraph If the baby is fed three hourly, for the first three months of his life which is desirable though not always practicable, the total divided by six will give the bulk of the individual feed In the case of weakly infants it may be advisable to give seven three hourly feeds, decreasing the amount of each When feeding is at four hourly intervals, as should be the case after the third month the day's total divided by five gives the amount of a single feed

The principles contained in these first three rules are of general application, but they must not be followed too slavishly The real test of whether a baby is getting enough is its satisfactory growth and the absence of indigestion Providing all is well with the infant, slight departures from its theoretical Caloric requirements can be safely neglected Whatever latitude is allowable these matters, one thing must not be interfered with, namely t regularity and punctuality of the feeding time Whether thre hourly intervals are chosen at say 6 0 a m , 9 0, 12 noon 3 0 p m 6 0 and 10 0 p m or four hourly at 6 0 a m 10 0, 2 0 p m , 6 0 ar 10 0 p m , the baby must be fed at identically the same time eac day Upon this depends to a great extent his chance of good dige tion and the success of any form of feeding selected

4 The method of feeding adopted must be *economically possibl* Those methods which require elaborate apparatus, such as steri izers and refrigerators, costly proprietary ingredients or great tim in preparation have no place except in the homes of the wealthy

5 The food offered *must be digestible* The differences betwee cow s milk and human milk already enumerated must be minimized

In modifying cow s milk the factors to be considered are th physical properties of its protein, the relatively greater amount o protein the relatively smaller amount of sugar and the relatively greater amount of mineral matter in that order of importance The greatest drawback of cow s milk as a food for young babies is the way its caseinogen behaves during the course of digestion Not only is there a large amount of it, but in the baby's stomach it tends to set into a firm indigestible clot In theory it should be possible to readjust the total and relative amounts of caseinogen

and lactalbumin. Practically, however, it is too tedious to do this as an everyday measure. Consequently it is usual to attack the physical properties of the proteins rather than their proportions so that they form a finer clot in the stomach. According to the way in which this is carried out, other additions may have to be made to the milk in order to maintain the Caloric value.

Methods of Modifying Cow's Milk

(1) *Heat.* If milk is boiled for five minutes, the caseinogen undergoes a change which makes it more easily digestible. Some of the protein is lost in the "skin" which forms and the total protein content is thereby slightly diminished. Similar changes can be brought about by heating the milk for a longer period at a lower temperature. In Budin's method of infant feeding the milk is heated for forty minutes at 212° F. The advantages of treating milk by heat are its simplicity, the unaltered food value (any loss of protein is counteracted by a loss of water) and the fact that the milk is rendered sterile. The disadvantages are the change in flavour, the destruction of the antiscorbutic vitamin, and the failure to raise the sugar content or diminish the amount of mineral matter. This method can be used successfully for feeding many healthy babies providing care is taken to replace the vitamins by other means, e.g. orange juice and cod liver oil. For weakly infants it is not the method of choice.

(2) *Dilution.* The object here is to reduce the caseinogen and mineral matters in cow's milk, to leave the proportion of fat much as it was, and at the same time to increase the amount of sugar. Taking the average composition of cow's milk and human milk, and adding one part of water to one part of cow's milk we get the following comparative results.

	Human Milk.	Cow's Milk.	Cow's Milk and Water equal parts
Protein	1 5	3 5	1 75
Fat	3 5	4 0	2 0
Sugar	6 5	4 5	2 25
Mineral matter	0 2	0 7	0 35

This makes the proportion of protein about right but leaves the sugar too low. If now one adds to every 4 oz. of the mixture one medium sized teaspoonful of milk or cane sugar pressed flat and one teaspoonful of 40 per cent. cream, these defects are rectified and, except for an excess of inorganic substances, the mixture will have approximately the same proportion of each ingredient as human milk.

The proportions of milk, water sugar, and fat can be altered to suit babies at different ages and in varying states of health Such variations on the theme of dilution provide the basis of the so called "formula feeding" Some dairies are prepared to carry out the dilution and reconstruction according to prescription and to deliver the milk ready modified A similar modification carried out commercially is the "humanized milk By diluting the milk with an equal quantity of water and subjecting it to the action of a centrifuge, it is divided into two equal parts, one of which contains practically all the fat of the original milk but only half the other ingredients The deficiency of sugar is remedied by the subsequent addition of that constituent in the necessary proportion The proportion of protein in such a milk will tend to be too low, and the inorganic substances still too high but otherwise the composition will correspond pretty closely to that of human milk

It is clear that all the methods of dilution have one defect, although they bring down the total amount of protein to the level at which it is in human milk, they *do not influence in any way the relative* proportions of the two kinds of protein—caseinogen and lactalbumin For this reason the resulting mixtures must remain more difficult of digestion and less useful in metabolism than human milk Various methods of getting over this difficulty have been proposed by using whey as a diluent but all such methods are rather troublesome

(3) *Acidifying* The physical properties of the protein can be modified in some respects by making the milk acid although the changes brought about are not exactly the same as those produced by heat, peptonizing or desiccation The proteins in cow's milk act when in contact with the gastric juice as if they were an alkali, immobilizing some or all of the hydrochloric acid in the juice The purpose of adding acid before hand is to exhaust this buffering action of the proteins Incidentally the size of the clot formed can be regulated by the manner in which the acid is added to the milk and there are also some more remote effects from the acid milk on the type of bacteria inhabiting the intestine *Of the* many possible methods of acidifying milk, two are in common use In one a measured quantity of milk souring bacteria is added to the milk which is kept at blood heat in a suitable apparatus (thermos flask or incubator) for twelve hours before use A small quantity of this soured milk may be used for starting the process in the next lot, though it is well not to carry this process through more than five generations before starting with a new supply of acidifying bacteria (see p 683)

The second, and perhaps simpler, method is the direct addition

of acid to the milk To each pint of boiled milk, which has been allowed to cool to blood heat (98 4° F), from 40 to 60 drops of 40 per cent lactic acid are added drop by drop with constant stirring In this way a very finely divided clot is formed in the milk which is not rendered unpalatable Care must be taken not to heat the milk above 40° C (104° F) after the acid is added, otherwise a dense curd will form When milk treated in this way encounters the acid gastric juice the caseinogen already clotted, cannot form in the stomach the massive curds produced by fresh cow's milk

(4) *Citrating* The digestibility of the caseinogen can be increased by the addition of citrate of soda in the proportion of 1 grain to every ounce of cow s milk This is reputed to act, by precipitating the excess of calcium salts and so causing the caseinogen to set into a less dense curd in the stomach

In the case of very young or weakly infants, it may be necessary to dilute the milk more freely than in the proportion given above In such a case a mixture of equal parts of milk water, and lime-water is to be recommended cream and sugar being added in proportionately larger quantity

(5) *Peptonizing* It is believed by some authorities that one of the essential differences between the caseinogen of human milk and that of the milk of the cow is that the former is really a stage nearer the digested condition (i e peptone) than the latter, and that the greater digestibility of human caseinogen is due to that fact Whether this be so or not, there can be no doubt that even the partial peptonization of cow s milk renders it much more easy of digestion Of *complete* peptonization there is no need to speak here It is of the greatest utility as a temporary expedient in some cases of disease or in feeble and exhausted babies but is not really required for healthy infants Sooner or later the stomach must be educated to deal with pure cow's milk and the sooner the education is begun the better Partial peptonization however may often be had recourse to with advantage as the first stage in this process of education in the case of infants whose stomachs have a greater difficulty than usual in dealing with cow s caseinogen It can be conveniently carried out by means of Fairchild s Peptogenic Milk powder (p 687) Each measure of the powder contains the ferment required to digest a certain quantity of milk along with some bicarbonate of soda which renders the milk slightly alkaline and enough milk sugar to raise that ingredient to the proportion found in mother s milk

By following the directions supplied with the powder the process of digestion is only carried so far as partially to change the caseinogen of the milk sufficient to prevent its clotting, but not enough

to absolve the stomach from all further labour Thus, digestion is rendered easy without the stomach's being demoralized Chittenden[1] *analysed the resulting mixture*, and compared it with human milk as follows

	Human Milk	Milk prepared by Peptogenic Milk powder
Specific gravity	*1031*	*1032*
Water	86 7	8[illegible] 0
Protein	2 0	2 09
Fat	4 1	4 38
Sugar	6 9	7 26
Mineral matter	0 2	0 26
Total solids	*13 2*	*13 0*
Reaction	Alkaline	Alkaline

It will be observed that the two fluids are almost identical in composition Milk prepared by this method does not clot with rennet, even in the presence of a considerable amount of acid

(6) ***Condensed Milk*** Condensed milk is simply cow's milk from which a large proportion of the water has been removed by evaporation under reduced pressure and with the aid of a greater or lesser degree of heat The milk is reduced to about one third of its original volume Sometimes whole milk is used for condensing At others, milk from which some of the cream has been removed is treated in this way, with or without the addition of sugar There are, therefore, the three following groups

(a) Unsweetened and condensed whole milk
(b) Sweetened and condensed whole milk
(c) Sweetened and condensed skim milk

(a) Of the unsweetened condensed whole milks often called evaporated milk, the following are examples [2]

	Total Solids	Protein	Fat	Milk sugar
Ideal	38 0	8 3	12 4	16 0
First Swiss	36 7	9 7	10 5	14 2
Viking	34 2	9 0	10 0	13 3
Hollandia	43 0	11 3	9 8	18 5
Libby s Evaporated Milk	31 0	10 0	9 4	11 7

[1] (1896) *New York Medical Journal* 54, 71

[2] Most of the analyses of condensed milks in this chapter are taken from PEARMAIN and MOOR s *Analysis of Food and Drugs* Part I pp 69–78

Carnation milk is an unsweetened evaporated milk in which 60 per cent of the water has been removed It is homogenized to break up the fat globules so as to make them resemble in size those of human milk and is finally sterilized

If 1 part of such a milk is diluted with 2 parts of water, the resulting fluid corresponds more or less closely to a good sample of pure cow s milk

(b) The sweetened condensed whole milks contain, as a rule, rather more added cane sugar than there are solids in the milk The following is the composition of some of the best brands, they are arranged, again, according to their richness in fat

	Total Solids	Protein	Fat	Milk-sugar	Cane-sugar
Nestlé	77 2	9 7	13 7	15 0	37 2
Rose	76 0	8 3	12 4	17 6	36 1
Milkmaid	76 3	9 7	11 0	14 6	38 7
Full Weight	76 5	12 3	11 0	13 5	37 2
Anglo-Swiss	74 4	8 8	10 8	16 0	37 1

There are many other brands in the market besides these, but none of them is superior to the above

Now, although the members of this group contain as much fat as the unsweetened condensed milks yet so much sugar has been added that if they are mixed with only as much water as has been removed in condensation, the resulting fluid would be so sweet that one could hardly drink it Hence a degree of dilution is recommended on the tins of these brands which renders it impossible for the resulting fluid to be at all like cow s milk in its proportion of protein and fat

(c) Of the condensed separated (or skim) milks there are an immense number in the shops They resemble in composition the second group just described, except in that they contain almost no fat (always less than 2 per cent) When diluted in the proportions recommended for infants the resulting fluid is very poor in protein and almost free from fat, *and is therefore entirely unsuited for a baby's nourishment*

It should be noted that the composition of all forms of condensed milk varies considerably owing to differences in richness of the original milk and to variations in the degree of condensation and in the amount of sugar which has been added This is borne out by the following table from a Report by Dr Coutts to the Local Government Board [1] which is based upon a large number of analyses taken from various sources

[1] *An Inquiry as to Condensed Milks with Special Reference to their Use as Infants Foods*, 1911

Variations in Chemical Composition of Certain Classes of Condensed Milk

	Full Cream				Machine skimmed Sweetened	
	Sweetened		Unsweetened			
	Lowest	Highest	Lowest	Highest	Lowest	Highest
Total solids per cent	68 1	83 6	29 2	38 0	56 9	79 1
Fat „	8 0	13 7	8 2	11 9	0 1	6 5
Protein	7 3	11 4	8 0	10 0	7 6	12 3
Mineral elements	1 6	3 4	1 6	2 5	1 6	2 9
Lactose	11 6	17 6	11 1	16 0	10 9	17 0
Cane sugar „	36 1	44 6	Nil	Nil	30 4	52 6

Digestibility of Condensed Milk

There is no doubt that condensed milk is more easily digested than fresh cow's milk When diluted in such proportion as to restore them to the condition of ordinary cow's milk, the condensed milks either do not clot with rennet at all, or the resulting curd is much looser than in the case of pure cow s milk [1] The presence of acid does not affect the result The explanation of these facts probably is that the caseinogen undergoes some chemical change in the process of condensation which renders it incapable of forming a dense clot Certainly this greater digestibility is one point in favour of condensed milk, and justifies its occasional use for infants who are entirely unable to digest ordinary cow s milk, even when specially modified [2]

Nutritive Value of Condensed Milk

The chief defect of condensed milks from a nutritive point of view is that they are apt to contain too little fat The unsweetened milks are alone satisfactory in this respect The skim milks are absolutely to be condemned on that account, and even the sweetened whole milks though they contain all the fat of the original milk yet require so great a degree of dilution, owing to the amount of sugar which they contain, that the product is notably deficient in

[1] The experiments were performed with the First Swiss brand and with Nestlé s

[2] The great degree of dilution in which condensed milk is usually given no doubt also explains in part the ease with which babies digest it

"The following table shows the character of the liquid—it cannot be called milk—that is produced by following out the directions on the labels of half a dozen of the best brands of (sweetened) wholecream milk" (Pearmain and Moor)

Sweetened Whole Milk.	Dilution recommended for Household Purposes.	Fat in such Product	Dilution recommended for Infants Use	Fat in such Product
A	1 to 3	2 6 per cent	1 to 5	1 8 per cent
B	1 5	1 6 "	1 14	0 7 "
C	1 5	1 6	1 14	0 6
D	1 6	1 4 "	1 " 15	0 7 "
E	1 5	2 1 "	1 " 14	0 8 "
F	1 5	1 7	1 14	0 7 "
G	1 5	1 7 "	1 " 14	0 7
Human milk	—	—	—	3 5

There can be no doubt that an immense amount of harm is done to infants by the indiscriminate use of such milks Babies fed on them may look fat enough, but they are pale and flabby, and often suffer from rickets, for fatness produced by abundance of sugar in the milk is, as has been already pointed out, by no means a sure indication of health, and the pictures of such fat but flabby infants so freely spread abroad by the makers of condensed milks are very deceptive

If a sweetened condensed milk is used at all it should only be for a short period (not beyond the first three or four months) and the deficiency of fat should be made good by the addition to the diet of cream or cod liver oil Babies of delicate digestion often do well for a time on Nestlé s milk in the proportion of two teaspoonfuls to six tablespoonfuls of water Such a mixture contains 1 13 per cent of protein 1 28 per cent of fat, and 4 72 per cent of sugar and by the addition of one teaspoonful of centrifugal cream to each feed the fat is brought up to 3 per cent The caseinogen in this mixture being very dilute, is easily digested, and the relative excess of sugar does no harm if such a method of feeding is not continued beyond the fourth month

The only kind of condensed milk which can be unreservedly recommended however is that made from whole cow s milk without the addition of sugar If 1 part of such a preparation is diluted with 2 parts of water, the product may be regarded as identical with good cow s milk and will therefore require further dilution sweetening and addition of cream just as fresh milk does

(p 549) Used in this way condensed milk is convenient in cases in which fresh milk is for any reason unobtainable or for temporary use in the case of infants who are unable to digest the latter

The question whether condensed milks are to be regarded as sterile or not is one of some importance Delépine found that the degree of heat to which they are subjected during condensation is not necessarily sufficient to kill all disease germs [1] On the other hand, Derning and Davis [2] conclude that evaporated milk may be regarded as for all practical purposes sterile

Some forms of condensed milk such as the whole cream evaporated milk are particularly adapted for irradiation by ultra violet light When this is done, as in the case of Carnation brand milk, the vitamin D content is enhanced to such a degree that not only is rickets prevented, but it may actually be cured If the condensed milk has not been irradiated, a daily ration of cod liver oil is necessary With any form of milk so treated, additional vitamin C in the form of orange, tomato, black currant, rose hip or swede juice must be given As a source of calcium and phosphorus condensed milk is quite satisfactory

(7) *Dried Milk* The water in milk can be removed and the solid part left as a powder This occupies about an eighth of the space of the original fluid, so that if one part of the powder is added to eight of water, the milk is reformed with the fat, protein, and carbohydrates in their original proportions In the course of drying especially if this be done by the roller process, the physical properties of the proteins are changed, when the reconstituted milk enters the stomach the curd formed is more finely divided and more digestible than that of fresh cow's milk This constitutes the chief claim of dried milk as a substitute feeding for young babies In addition, it is free from dangerous organisms easily handled and contains all the vitamins of fresh milk except the vitamin C Many manufacturers add vitamins to the milk powder, so that in use it has actually a higher proportion of accessory food substances than fresh unheated cow's milk

The varieties of dried milk have become rather confusing for beside the powder from whole cow's milk and milk from which half or all the fat has been removed, there are available the dried form of many modifications of cow's milk These modified dried

[1] See *Report to the Local Government Board upon the Effects of Certain Condensing and Drying Processes used in the Preservation of Milk upon its Bacterial Contents* by Dr S Delépine (Food Reports No 21) 1914

[2] (1931) *Archives of Pediatrics* 48, 42

milks have a vast range of compositions They may be grouped very roughly as follows

(a) With added sugar, with or without the removal of some of the fat
(b) With the proportions of the proteins altered more or less to resemble those of human milk
(c) With the total protein either increased or decreased above that normally present in cow s milk
(d) With the addition of acid, with or without the removal of some of the fat
(e) With the addition of substances such as iron, to combine feeding with therapy
(f) With the addition of more complicated carbohydrates than sugar

The graduation from the simpler to the more complex milk powders could be continued into another group of dried foods The latter for the most part consists of sugars dextrins and more or less modified starches which in use have to be added to cow s milk They include, also foods derived from dried vegetables This group is of more service at the time of weaning than as a substitute for human milk in early infancy In the next Chapter representative examples of the simpler, as well as the more complex foods are set out In choosing a dried milk for a young baby it is well to avoid those which contain unmodified starch for up to the age of six months a baby has little power to break down starch to sugar In general it is perhaps best to choose a simple dried milk and to add to it such extra sugar as may be thought necessary Many of the milk powders containing added substances such as iron, almost cease to be foods and become food and medicine, their use needs medical supervision

From what has been set out above it is clear that there are several ways of providing a substitute for human milk From the fact that there are so many one may safely conclude that no one of them is ideal They should be used only under the pressure of necessity The home conditions of the baby and the amount of time and money that can be spent in preparing his food will play a part in deciding the most suitable form to use in each instance The substitute for human milk may be expected to give him a reasonable chance of survival but it must be remembered that it remains at best a poor second to his natural food For a baby less than seven months old human milk must be the only desirable

food Quite apart from its quality as the one really digestible food it has other advantages Among these may be mentioned its cheapness, accessibility and sterility No other food can be found which can be "kept on tap" so near the baby and which needs so little preparation to ensure its freedom from infection

CHAPTER XX

THE PRINCIPLES OF FEEDING IN INFANCY AND CHILDHOOD (*continued*) PROPRIETARY FOODS FOR INFANTS FEEDING OF OLDER CHILDREN

There are many proprietary foods for infants available on the market[1] The list which follows is not exhaustive, it may serve to illustrate the variety which exists in their composition The values given in the table refer to the proportions of water, protein fat and inorganic substances in the dry powder before it has been prepared for use They are the figures supplied by the manufacturers Care is taken that a product does not depart significantly in its analysis from the figures supplied From time to time, however different producers decide deliberately to alter the composition of a food It is advisable, therefore to enquire before a food is chosen whether any such modification has recently taken place The composition of the food should be clearly stated on the label

The foods fall into two main groups the first those which are to be made up with water before use, and the second those intended to be added to milk Generally speaking the former are mixed with water in the proportion of one part of food powder to eight of water This does not always apply, and the directions of the manufacturer should be consulted about the quantity of water to be used The object aimed at with many of the modified dried milks is to provide when they are made up a fluid whose composition closely resembles that of human milk Clearly therefore the proper dilution with water is as important as the preparation of the powder

[1] When this edition was revised (1945) many of these products were not readily available owing to the exigencies of war They have nevertheless been included for they or their successors will again become of practical importance In the meanwhile many firms have pooled their dried milk as National dried milk The composition of this latter whether full cream half cream or skimmed (household) corresponds very closely with that of similar status among the proprietory kinds

TABLE SHOWING THE COMPOSITION OF INFANT FOODS

Food	Water	Protein	Fat	Carbo hydrate	Inorganic Salts	General Description and Remarks
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	
Dried human milk	—	12 8	29 9	55 6	1 7	A standard of composition with which artificial substances may be compared
GROUP I (1)						
Ambrosia Full Cream	1 91	26 72	28 00	37 80	5 52	Full cream dried milk
Cow and Gate Full Cream	2 5	26 6	27 3	37 6	6 0	,,
Dorsella Full Cream	2 7	27 2	26 2	37 1	6 0	,, ,,
Ostermilk No 2	2 9	24 9	26 5	38 5	5 6	,, ,,
(2)						
Cow and Gate, Special Half Cream	2 5	30 3	16 5	43 8	6 9	Unmodified half cream dried milk
(2a)						
Ambrosia Half Cream	2	20 5	15 0	57 50	5 0	Half cream dried milk with added sugar
Allenbury Half Cream Food	2 4	[illegible]	9	72 6	—	With modified protein malted extract of wheat, and diminished fat
Cow and Gate Half Cream	2 5	20 0	15 0	58 0	4 5	Half cream dried milk with added sugar
Ostermilk No 1	2 0	17 0	20 0	56 0	3 9	Dried milk with diminished fat and modified protein
Sprulac	3 0	32 5	10 5	46 5	7 5	Diminished fat and increased protein
Casumen Milk Protein Food	6 5	38 1	10 7	41 1	3 6	Dried milk with added protein and carbohydrate

(3)						
Cow and Gate Separated	3 0	35 5	0 8	52 8	7 9	Dried skimmed milk.
(3a)						
Seeway	—	13 0	1 0	76 0	9 0	Dried whey
Allenbury s Sweet Whey	—	13 2	1 2	75 0	—	" "
(3b)						
Casumen	4 50	89 2	2 4	—	3 90	Milk protein.
Protosol	—	91 5	1 9	—	—	
(4)						
Allenbury s No 1	2 5	10 8	18 5	63 4	4 1	Dried milk from which some casein has been removed and dextrin maltose added
Allenbury s No 2	2 6	11 6	17 5	63 8	3 9	Similar but with more protein and with malted extract of wheat
Cow and Gate Humanized	2 0	15 5	26 5	52 5	3 5	Dried milk with modified protein and added sugar
Humanized Dorsella	2 9	12 38	25 93	55 62	2 9	Similar
Humanized Ambrosia	2 9	16 4	20 0	57 6	4 0	
Humanized Trufood	1 0	11 95	29 3	52 25	5 2	Dried milk with modified caseinogen—lactalbumin ratio and with added sugar
Geego Full Cream	3 0	17	17	58 0	4	Milk dried *in vacuo* by special process with added sugar
Half Cream	3 0	19	10	62 0	4 5	Similar, with less fat
Separated	3 0	22	0 12	69 0	5	Similar with fat removed
Neave s Milk Food	2 4	20 0	26 0	47 1	4 5	A mixture of dried milk lactose and maltose

TABLE SHOWING THE COMPOSITION OF INFANT FOODS

Food	Water	Protein	Fat	Carbo hydrate	Inorganic Salts	General Description and Remarks
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	
Dried human milk	—	12 8	29 9	55 6	1 7	A standard of composition with which artificial substances may be compared
GROUP I (1)						
Ambrosia Full Cream	1 91	26 72	[illegible] 00	37 [illegible]	5 52	Full cream dried milk
Cow and Gate Full Cream	2 5	26 6	27 3	37 6	6 0	,, ,,
Dorsella Full Cream	2 7	27 2	26 2	37 1	6 0	,, ,,
Ostermilk No 2	2 0	24 9	26 5	38 5	5 6	,,
(2)						
Cow and Gate Special Half Cream	2 5	30 3	16 5	43 8	6 9	Unmodified half cream dried milk
(2a)						
Ambrosia Half Cream	2	20 5	15 0	57 50	5 0	Half cream dried milk with added sugar
Allenbury's, Half Cream Food	2 4	12	9	72 6	—	With modified protein malted extract of wheat, and diminished fat
Cow and Gate Half Cream	2 5	20 0	15 0	58 0	4 5	Half cream dried milk with added sugar
Ostermilk No 1	2 0	17 0	20 0	56 0	3 9	Dried milk with diminished fat and modified protein
Sprulac	3 0	32 5	10 5	46 5	7 5	Diminished fat and increased protein
Casumen Milk Protein Food	6 5	38 1	10 7	41 1	3 6	Dried milk with added protein and carbohydrate

(3)						
Cow and Gate Separated	3 0	35 5	0 8	52 8	7 9	Dried skimmed milk.
(3a)						
Seeway	—	13 0	1 0	76 0	9 0	Dried whey
Allenbury s Sweet Whey	—	13 2	1 2	75 0	—	"
(3b)						
Casumen	4 50	89 2	2 4	—	3 90	Milk protein.
Protosol	—	91 5	1 9	—	—	"
(4)						
Allenbury s No 1	2 5	10 8	18 5	63 4	4 1	Dried milk from which some casein has been removed and dextrin maltose added
Allenbury s No 2	2 6	11 6	17 5	63 8	3 9	Similar but with more protein and with malted extract of wheat
Cow and Gate Humanized	2 0	15 5	20 5	52 5	3 5	Dried milk with modified protein and added sugar
Humanized Dorsella	2 9	12 38	25 93	[illegible] 62	2 9	Similar
Humanized Ambrosia	2 9	16 4	20 0	57 0	4 0	
Humanized Trufood	1 0	11 95	29 3	52 25	5 2	Dried milk with modified caseinogen—lactalbumin ratio and with added sugar
Geego Full Cream	3 0	17	17	58 0	4	Milk dried in vacuo by special process with added sugar
" Half Cream	3 0	19	10	62 0	4 5	Similar, with less fat.
Separated	3 0	22	0 12	69 0	5	Similar with fat removed
Neave s Milk Food	2 4	20 0	26 0	47 1	4 5	A mixture of dried milk, lactose and maltose

TABLE SHOWING THE COMPOSITION OF INFANT FOODS—*continued*

Food.	Water	Protein	Fat	Carbo hydrate	Inorganic Salts	General Description and Remarks
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	
(4a)						
Almata	—	12 5	25 0	56 6	2 6	A dried food derived from egg yolk, casein, butter and malto dextrin of a composition similar to breast-milk
Veguva No 1	1 2	16 0	15 0	65 0	2 8	Dried cow s milk to which a mixture of specially prepared carbohydrates has been added, also sodium caseinate, egg yolk, yeast, and the juices of carrot and tomato
(5)						
Lacidac Full Cream	2 5	25 5	26 5	36 0	6 0	Dried full cream milk with added lactic acid 3 5% of powder
Half Cream	2 5	29 0	16 0	42 5	6 5	Similar with less fat
Separated	3 0	34 0	0 7	51 3	7 5	Similar without fat
Allerglac	3 0	[illegible] 8	18 0	43 5	7 0	Dried milk with diminished (1 0%) lactalbumin and [illegible] 7% (in powder) lactic acid
Prolac	2 55	40 0	19 5	29 5	6 5	Dried bacterially soured milk.
Beurlac	3 0	31 0	9 0	46 5	7 5	Similar with less fat and more sugar
Mead Johnson Protein Milk	—	39 0	26 5	24 0	—	

(6) Ambrosia with added iron	1.91	26.72	[illegible]5.00	37.85	5.52	Full-cream dried milk to which iron is added as iron and ammonium citrate in two strengths either 31½ or 60 grains to the pound of the powder
Dorsella with added iron	2.7	27.2	26.2	37.1	6.0	Similar, with 31½ grains of iron and ammonium citrate to the pound of the powder
Ferrolac Full Cream	2.8	24.9	26.5	38.5	5.8	Full-cream dried milk with a therapeutic amount of iron added
Ferrolac fat modified	2.0	17.0	20.0	56.0	4.1	*Similar, with diminished fat and added sugar*
Hemolac	2.45	26.50	27.20	37.50	5.90	Full-cream dried milk with 31½ grains of iron and ammonium citrate to each pound of the powder
GROUP II (1) Benger's Food	5.3	12.2	0.9	80.3	1.0	When mixed with milk as directed all but 0.5% of the carbohydrate becomes soluble. At the same time the casein is modified by the trypsin present in the powder
Modilac	2.0	18.6	19.0	56.3	4.1	A dried milk with added cane-sugar and dextrin to be mixed with water
Peptolac	3.0	33.4	7.3	49.7	6.6	Similar, with added protein and starch splitting ferments
Mellin's Food	6.3	7.9	Trace	82.0	3.8	A completely malted food with all the carbohydrates in a soluble form. May be regarded as a dried malt extract

Fourth Meal 5 p m

Same as first

Fifth Meal 9 to 10 p m

Warm milk

During this period the use of a bottle should be gradually discontinued and the child fed with a spoon or accustomed to drink out of a feeding cup or ordinary cup

The amount of milk taken in the course of the day should not exceed ▮ pints If the child is thirsty, he may be given a little water between meals

From about the eighth month onwards something to chew should be given occasionally such as a rusk or crust, or a piece of sponge cake or stale bread and butter

Two teaspoonfuls of orange juice may be given daily and in the winter months some fish liver oil

II Diet from 12 to 18 Months

First Meal 7 30 a m

A breakfast cupful of milk thickened with groats fine oatmeal *whole-wheat flour or hominy*

Bread or rusks and milk as a change bread fried in bacon fat

Second Meal about 11 a m

A cupful of warm milk

Third Meal 1 to 1 30 p m

Sieved potato and vegetables with gravy and scraped meat or pounded fish as a change the yolk of a lightly boiled egg

Some milky rice or bread pudding with the addition of some of the pulp of a roasted apple or the pulp of stewed prunes

Fourth Meal 5 p m

Milk and bread and butter and plain cake

Fifth Meal 9 p m[1]

Warm milk

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[1] The sooner this late drink can be omitted the better It delays the acquisition of nocturnal continence of urine *Its place must be* taken by bigger drinks of milk earlier in the day

III Diet from 18 Months to 3 Years

First Meal 8 a.m.

Porridge and milk followed by the yolk of a lightly boiled egg or bread dipped in bacon fat Stale bread crisp toast or a rusk.
Milk to drink.

Second Meal 12 30 to 1 p m

A little pounded or minced chicken or underdone meat or fish with green vegetable and mashed potato
Milk pudding and stewed fruit
Water to drink.

Third Meal 4 30 p.m

Bread-and butter sponge or other plain cake occasionally
Milk.

Fourth Meal 6 30 p.m

Warm milk or milk soup

A little fresh fruit should be given daily and some fish liver oil in the winter

CHAPTER XXI

THE PRINCIPLES OF FEEDING IN DISEASE

In this and the succeeding chapter we shall consider the use of *food as a therapeutic agent in the treatment of the sick* In dealing with this part of the subject, it will be well to confine our attention as far as possible to the discussion of principles, and to avoid those detailed instructions for the dietetic management of particular cases which find their appropriate place in text books of therapeutics If the general principles involved are once fairly grasped, the knowledge we have already acquired as to the composition and uses of *different foods should be sufficient to guide us in drawing up* a dietary suited to any ordinary case of illness Nor can one deal in such a book as this with the methods of preparing food for the sick, or invalid cookery, no matter how important some acquaintance with that art must always be to the practical physician

In deciding upon the dietetic management of any case of disease it is important to bear in mind what is often forgotten, that a patient is not a mere bundle of separate organs, but an organic whole and *that the diet must often be directed to the needs of the man rather* than to those of his malady The evil results of a forgetfulness of this fact are often seen A patient's general nutrition may become seriously impaired, for instance, through well intentioned efforts to lighten the labours of his stomach Thus it has only just been realized that many of the diets used in the treatment of gastric disorders are either wholly deficient or contain a minimum of ascorbic acid Patients who have had these diets for some time are in the subscurvy state as shown by the amount of ascorbic acid they assimilate before the excess is excreted in the urine (see p 164) The important factor of idiosyncrasy must also be borne in mind, and *full recognition made of the fact that different* individuals react differently to the same diet just as they do to the same drugs Nor must it be supposed as *the laity are apparently tempted to* do, that diet is a universal panacea which can be counted upon to prevent or to cure all diseases On the contrary, it *has like*

other remedial agents, only a limited place in therapeutics, and the few diseases which specially lend themselves to dietetic treatment may be divided into the following groups (1) Fevers, (2) disorders of metabolism, e g diabetes, obesity, gout, (3) affections of the stomach and bowels, (4) disorders of the circulation and blood, (5) diseases of the organs of excretion

But before one passes to the separate consideration of these groups, it is advisable to point out a few *practical rules* which should always be present in one's mind in drawing up any scheme of diet for a patient They are these

1 A special plan of diet must be drawn up and the foods which are forbidden must be specified In a few cases, only the latter need be mentioned

The next two rules are corollaries to the first

2 Before recommending any food it is well to ascertain whether the patient likes it, and how it agrees with him

3 A food should not be forbidden unless there is a good reason for so doing

4 Unless there is some strong contra indication attention should always be paid to the wishes and tastes of the patient This rule was first formulated by Hippocrates in the aphorism "Such food as is most grateful, though not so wholesome, is to be preferred to that which is better but distasteful", and Sydenham recognized its value when he wrote "More importance is to be attached to the desires and feelings of the patient, provided they are not excessive or dangerous, than to doubtful and fallacious rules of medical art"

5 If food disagrees it should be deleted from the dietary and later on given in small amounts If this is well tolerated the quantity taken can be increased

6 Changes of diet should if possible be made gradually

7 A diet should never be prescribed for a patient without having first ascertained what his habits are as regards work and exercise

These rules require no comment

1 *Principles of Diet in Fever*

There are few departments of practical medicine in which opinion has undergone a greater revolution than in the question of fever diet [1] Hippocrates fed his fever cases simply upon wine and "ptisan" or thin barley gruel and this lowering plan first practised for centuries on the sole weight of his authority, was afterwards

[1] For a full account of the history of the subject see J UFFELMANN, (1877) *Die Diät in den Acut fieberhaften Krankheiten*

endorsed by the erroneous pathological doctrine first promulgated by Broussais, that fevers proceeded from irritation of the intestinal mucous membrane and therefore demanded a starvation diet His contemporary, Brown though perhaps not much nearer the truth in his pathology, was better advised in his practice when he taught that fevers were "asthenic" diseases, and required to be treated by liberal feeding It was not until about the middle of the nineteenth century, however, that Graves, discarding all pathological doctrines, and guided simply by the results of observation, came to the conclusion that the popular starvation method was wrong, and introduced the modern practice, ever since adopted, of "feeding fevers"

The prevailing system at the present time may be fairly described as that of feeding a fever patient up to the limits of his digestive capacity with fluid or semi fluid food, except, perhaps, in the case of some abdominal conditions The reaction against starvation diets, in the opinion of some physicians has gone too far, while others are of the opinion that even now insufficient amounts of food are given

Any lingering doubts as to the wisdom of the feeding plan tend to be dispelled by the results of researches which have shown (1) that the free administration of food does not, as was formerly supposed, tend to raise the temperature of feverish patients, and (2) that the food is not merely poured into a digestive apparatus unable to deal with it, for the absorption of light articles of diet, at any rate, goes on as perfectly in the febrile as in the non febrile state

It has been shown that a great increase of metabolism occurs during fever and Coleman and Du Bois [1] found in cases of typhoid fever that the basal heat formation rises and falls in a curve roughly parallel with the temperature and at the height of the fever is 40–50 per cent above the normal

It is important to consider how the calorie requirements are supplied If a healthy patient is starved the fat and protein of the body supply the bulk of the Calories which are produced Thus Benedict [2] estimated the metabolism of a starving healthy man, and the average figure for the seven days showed that 1690 Calories were used per day and these were supplied by 139 8 grammes of fat, 69 5 grammes of protein and only 23 6 grammes of carbohydrate The chief loss of weight is due to the consumption of fat though the weakness of the muscles attracts especial attention to the destruction of protein In the seven days of the fast 486 5 grammes of

[1] COLEMAN W and DU BOIS E F (1915), *Arch Int Med* 15 887

[2] Cit GRAHAM LUSK (1928) *Science of Nutrition* Fourth edition,

protein were used which must have come from the muscles, this figure multiplied by 4 8 gives the weight of flesh lost, i e 2 33 kilogrammes = 5 12 lb The loss of muscle is well shown by F von Muller's experiment He gave a patient a diet of 1000 Calories containing 51 8 grammes protein (8 29 grm nitrogen) The patient lost on balance 86 4 grammes of nitrogen in 8 days and this is equivalent to a loss of 540 grammes of protein or 2 59 kilogrammes of flesh (5 7 lb)

METABOLISM OF S.A B DURING A SEVEN DAY FAST
(after Benedict)

Day	Grammes.			Calories.				R.Q	Urine.	
	Protein.	Fat.	Glycogen.	Calculated from Metabolism.	Directly Determined.	Per kg	Per Sq.M		Ratio N S	Ratio N P O_5
1	73 4	1 6-4	64 9	1796	1765	29-7	941	78	19-6	8 55
2	74 7	147 5	"3 1	1790	1768	29-9	946	75	18 6	5 55
3	"8-1	1 3 0	5 4	1783	1797	30-8	952	74	17 38	6 34
4	62-8	144 7	25 2	1734	1775	30-8	966	75	16 11	4 83
5	65 2	144 7	8 2	1636	1640	29-0	903	74	16 .6	5 23
6	64 4	1 9 8	21 7	1547	1653	27 5	656	76	16-27	5 19
7	60-8	[illegible] 5	18 7	1546	1 68	28 0	669	74	16-28	4 87
Average	69-5	139-8	23 6	1691	1696	9 3	9.2	75	17 2	5 .9

The work of Shaffer and Coleman,[1] and Coleman and Du Bois [2] on the metabolism of typhoid fever has shown that the average metabolism of a patient with typhoid fever is 40 Calories per kilogramme or 2400 for a man of 65 kilogrammes (10 stone 3 lb) They found that the basal metabolism might be increased by 40–50 per cent when the temperature was 104° F (8 per cent for each degree Fahrenheit) A healthy man was easily kept on a nitrogenous equilibrium on this number of Calories but the typhoid patient required 52–80 Calories per kilogramme (3600–5000) It is difficult to understand what happens to this great excess of Calories Coleman and Du Bois showed that the protein, fat and carbo hydrate were perfectly digested and absorbed and that some fat might be deposited in the tissues although protein loss was con tinued They also found that the specific dynamic action of protein was much reduced or even absent The great disturbance in metabolism is believed to be due to the action of toxin and not

[1] SHAFFER P A and COLEMAN W (1909) *Arch Int Med* 4, 538
[2] COLEMAN W and DU BOIS E F (1915) *Arch Int Med* 15, 887

of puddings made with rice or semolina, mashed potatoes and gravy, and oatmeal, or the proprietary foods like Benger's or Farex The extra fat should be given in the form of cream 300–400 c c of 20 per cent cream The feeds should be given two hourly by day and four hourly by night

When this high Caloric diet is used a careful watch must be kept on the stools for signs of undigested material and if these appear the amount of food should be reduced, and in some cases very considerably We have taken typhoid fever as our type, but the same principles apply to other fevers and the convalescence from these would be much shorter if more food were given A patient with influenza often has little appetite and does not want to eat meat or fish, but eggs can be added to milk and 200–400 grammes of sugar can be added to lemon or orange drinks, and thus raise the caloric value considerably Even in a short fever at least 2000 Calories should be given if possible and in a long one this should be increased to over 3000 Fish and meat should be given as soon as the patient's appetite returns but in rheumatic fever meat and meat extracts should not be given

The use *of alcohol* in fevers is an important matter which calls for some special discussion Hippocrates recognized the value of wine in fever and since his time it has been pretty generally employed Stokes of Dublin laid down certain imperative indications for its use, and his colleague Graves devoted one of his clinical lectures to a consideration of the place which it should take in the general treatment of fever The advantages of alcohol, however, were insisted upon more strongly by Todd,[1] about the middle of the nineteenth century than by any preceding English author By the end of the nineteenth century the administration of brandy had become a routine treatment and 1, 2 or 3 oz were given every four hours to most of the ill patients and even to young children Since then opinions about the use of alcohol in disease have altered considerably

Alcohol was strongly recommended for the following conditions

(1) Failing circulation as exhibited (i) in a persistently rapid pulse (120 or more) or if it be weak irregular, unequal or dicrotic (ii) by a faint or inaudible first sound of the heart [2]

It is difficult to understand how alcohol can be of much value in any of these conditions Higgins showed that alcohol causes a slight quickening of the pulse rate and that this may last for thirty minutes This quickening suggested that the myocardium was definitely stimulated by the alcohol and Dixon working on the

[1] *Clinical Lectures on Certain Acute Diseases* London 1860 Page 438

[2] STOKES (1839) *Dublin Med Journ* (1st series) 15, 1

isolated rabbit heart observed a slight stimulant action This is denied by other workers and would in any case be of little value The blood pressure does not rise after alcohol because it has no direct stimulant action on the vaso motor centre, but if the amount taken is sufficient to cause excitement the blood pressure may rise Alcohol produces a change in the distribution of the blood since the skin becomes red and flushed This increased blood supply to the skin would cause a greater pulsation in the radial artery, and would suggest that alcohol was a cardiac stimulant

These considerations suggest that no reliance should be placed on alcohol for the treatment of cardiac affections

(2) Nervous exhaustion, as manifested by sleeplessness low delirium, and tremors Alcohol has a depressing effect on the higher centres of the brain The depression which results therefrom is often of value in aiding sleep as the patient becomes more tolerant of his troubles If the patient is unaccustomed to alcohol ½ or 1 oz of whisky may be sufficient to ensure sleep but if he habitually takes 4–6 oz at bed time smaller amounts will be valueless A low delirium and tremors would probably be made worse by alcohol

(3) Failure of digestive power as indicated by inability to take food and diarrhœa Alcohol is often taken by patients who suffer from indigestion as they are thereby enabled to eat their meals better This is a bad practice as the patient is thereby induced to eat food which his stomach cannot tolerate and is better without Further, alcohol by itself tends to cause a gastritis and so intensifies the damage already done to the stomach It has no effect in checking diarrhœa

(4) High temperature especially if persistent Alcohol is of some value in lowering the temperature as it dilates the peripheral vessels and therefore causes an increased loss of heat It is now recognized that the fever is often beneficial to the patient and (unless the patient is in danger of developing a hyperpyrexia, i e a temperature rising rapidly to 108°) alcohol should not be used for this purpose

(5) A bad general condition—e g in feeble exhausted elderly, or alcoholic subjects Alcohol is frequently given under these conditions and may induce the patient to take food which he would not otherwise do It should not be pressed on patients if they dislike it as its real value is very small It is often necessary to give it to patients who feel miserable or who cannot sleep without any alcohol but it should only be given in small amounts If a patient cannot eat his meals without alcohol it is probable that some definite lesion of the stomach is present and the patient should be examined from this point of view

(6) *As a food* Alcohol has a high Caloric value as 1 gramme yields 7 Calories It is, however, burnt very slowly in the body, *only 10 c c* (8 grammes) of absolute alcohol can be oxidized an hour and these yield 56 Calories This amount is given by ⅝ oz of brandy, 45 per cent, or 1⅓ oz of whisky (post war) 20–25 per cent The maximum amount of brandy which could be oxidized in twenty four hours is thus 16 oz (whisky 32 oz) and would contain 192 *grammes of absolute alcohol* This amount of alcohol would yield 1344 Calories A patient, who was unaccustomed to alcohol, would be made very drunk although a seasoned toper might be unaffected It is probable that ½ oz of brandy every four hours by day and once in the night (i e 6 doses) is as much as most patients can stand, *though double or treble the dose used to be given* This would give 36 grammes in the day and 252 Calories This number of Calories is supplied by 61 grammes of sugar and is better tolerated by all patients unless they habitually take large amounts of alcohol It must be remembered that all the alcohol is not burnt, *for some of it is excreted in the urine and is thus lost*

The Kind of Alcohol Some authorities have laid great stress on the types of alcohol used They believe that a preparation rich in volatile esters like genuine cognac is much better than ordinary brandy or whisky, but there is no pharmacological evidence that this is the case A good dry champagne has been recommended in the treatment of vomiting and was formerly much used

The views about alcohol are those which we have formed from the consideration of the physiological evidence and of the medical experience of one of us, but we thought it desirable to consider the current practice as shown by the amount of wines and spirits ordered in eight different hospitals

Cost of Alcohol consumed at Nine Hospitals

Hospital	No of Beds in 1938	1903 £	1908 £	1913 £	1918 £	1923 £	1928 £	1933 £	1938 £
A	670	717	559	323	482	644	281	72	[illegible]
B	300	77	42	31	86	182	115	65	51
C	673	171	48	28	112	172	180	[illegible]	73
D	649	368	133	238	276	303	174	123	102
E	849	545	298	143	381	510	393	168	125
F	476	246	79	70	80	164	140	205	182
G	436	—	—	—	—	481	345	424	259
H	601	224	97	88	205	522	438	207	332
I	642	—	—	136	291	252	272	316	374

The table shows the cost of the wines and spirits at nine hospitals in London and big towns, and is the actual cost in the years 1903, 1908, etc The number of beds shown is the figure for 1938, and in many cases is greater than it was in 1903, and in one case (H) is nearly double, owing to the presence of many patients with cancer The price of alcohol was much greater in the years immediately after the 1914–1918 war than it was before then

The results are interesting and show that in six out of eight hospitals the consumption is considerably smaller than it was in 1903, but that the decrease is very uneven Thus in one big hospital the cost in 1903 was £717, the biggest figure of the series and is now only £20, while in a small hospital the cost was £77 and has only decreased to £51, in another big hospital it has decreased from £515 to £125 In two hospitals however, the opposite has taken place and the cost in one case has risen from £224 to £332, but it must be pointed out that the number of beds has nearly doubled and now includes many patients dying of cancer The figures for the other hospital are most remarkable as they have risen from £136 in 1913 (figures for 1903 are not available) to £374 in 1938 or nearly fourteen times as much as that of hospital A which has about the same number of beds

On the whole, the figures for the hospitals are in agreement with the views we have set out

The figures for the different kinds of alcohol used in hospital A in 1903 and the succeeding years are shown on page 584, together with that used in 1938 in four other hospitals, and reflect the opinions in the different hospitals

The figures vary in a surprising way Brandy is most used in all five, but apart from this there is no common factor and the figures must be allowed to speak for themselves

The figures for beer and stout are not included in the table on the opposite page The consumption of these is still considerable, for at St Bartholomew's Hospital the cost is about £60 a year They are chiefly prescribed for elderly patients (usually after surgical operation) who either cannot sleep at night or are miserable without their beer Many of these patients are accustomed to drink a good deal of beer

8 *Disorders of Metabolism*

The Dietetic Treatment of Diabetes Mellitus

The change which has taken place in the dietetic treatment of diabetes mellitus since this book was first published in 1900 is very remarkable At that time the patients were given a diet con

COMPARISON OF CONSUMPTION OF STIMULANTS 1903–38

	Port			Sherry			Gin			Burgundy Bottles			Whisky			Brandy			Rum			Champagne Bottles (½)
	G	P	Oz	G	P	Oz	G	P	Oz				G	P	Oz	G	P	Oz	G	P	Oz.	
1903	414	1	5	5	5	13	3	5	16	33			23	7	10	370	6	15	1	2	2	98
1908	230	2	4	1	2	13	1	1	0	120			12	0	19	260	5	5	—	—	—	184
1913	212	2	3	20	7	15	2	0	10	38			2	1	2	233	4	13		2	0	147
1918	154	7	1	—	—	—		6	12	91			1	2	17	166	1	2	1	1	0	126
1923	103	5	4	3	4	0		3	0	46			2	5	0	77	7	4		3	0	104
										G	[illegible]	Oz										
1928	10	5	5		4	9	1	4	7	3	6	15		3	16	66	3	9			10	85
1933	4	5	4	—	—	—			6	1	5	4	—	—	—	11	2	3	—	—	—	17
1938	1	4	12	1	0	12	—	—	—	2	0	0		3	13	5	7	12		2	12	10

The figures for four other hospitals in 1938 were as follows

	Port			Sherry			Gin			Burgundy			Whisky			Brandy			Rum			Champagne
E	14	3	10	10	7	9	1	[illegible]	3	0	6	0	7	0	12	19	5	13	0	1	8	[illegible]
F	0	7	4	—	—	—	—	—	—	3	0	0	1	7	1	47	3	6	—	—	—	16
K	—	—	—	—	—	—	—	—	—	2	0	13	0	3	14	6	4	12	—	—	—	37
L	0	[illegible]	6	0	1	0	0	0	4	0	2	10	0	3	6	28	16	9	—	—	—	46

taining 100–150 grammes of protein, 250 grammes or more of fat and very little carbohydrate The protein of the diet was high because of the different so called diabetic foods which were eaten The best of these contained no carbohydrate at all though in many of them the carbohydrate was little reduced The former were unpalatable whereas the latter were less so, in proportion as they contained more carbohydrate

If an abrupt change was made from an ordinary diet to a very strict one the glycosuria disappeared in the mild cases, whereas coma might rapidly supervene in the severe ones Such tragedies led to a change in treatment and the carbohydrate was gradually reduced from 100 grammes to 20 grammes In the mild cases the thirst and glycosuria disappeared and the patients health improved. But if a patient had a severe diabetes the amount of acetone bodies gradually increased and sometimes exceeded 50 grammes in the day, while the glycosuria did not disappear Van Noorden introduced an improved treatment for this type of case This consisted of a diet of eggs vegetables, and butter which was eaten for two days followed by one of 150 grammes of well cooked oatmeal and 200 grammes of butter for another two days, and then by the egg and vegetable diet for another two days This régime was unpleasant, but always caused a great decrease in the acetone bodies and glycosuria, but as soon as the original high protein and fat diet with little carbohydrate was given the condition rapidly deteriorated.

Guelpa introduced the fasting treatment which he combined with saline purgatives This treatment caused the disappearance of the glycosuria but it returned as soon as the original diet was given

F M Allen s striking contribution was the gradual increase in the diet after a fast of sufficient duration to get rid of the glycosuria The fast might only be of two or three days duration but might last ten days or longer in severe cases before the glycosuria dis appeared When this occurred the protein and fat of the diet were gradually increased but the carbohydrate was kept at 20–30 grammes in the day If the glycosuria returned a further fast was prescribed until it disappeared This treatment was a great advance on the old treatment and patients often ceased to pass sugar although the carbohydrate in the diet was raised to 50 grammes or more In the severe cases the diet would consist of C 20–40 grammes, P 100 grammes, and F 125–200 grammes caloric value 1700–2400 The condition tended to relapse and the patients with the severe disease gradually lost weight strength and energy though this was partly due to the repetition of the fast necessitated by the return of glycosuria This state of under

nutrition although of great immediate benefit to the patient caused great privations Some workers thought that the effect of the under nutrition was worse than the disease and in 1922 had already abandoned the fasting treatment for a so called maintenance diet which contained C 40–50 grammes, P 70–80 grammes F 125–150 grammes, calories 1600–1900 The introduction of insulin by Banting and Best in 1922 caused such a great improvement in the general health of patients that at first little change in the composition of the diet occurred This was partly due to the high cost of insulin, 25*s* per 100 units compared with the present price of 1*s* 6*d* per 100 units

In 1926 Sansum and others [1] reported the case of a man who said that he must have more carbohydrate in his diet They found that the patient was much better in health when given more carbohydrate and more insulin, and that the amount of insulin required was much less than anticipated Since that time the amount of carbo hydrate has been steadily increased and now varies from 150 to 250 or even 350 grammes, co incidentally the amount of fat has been decreased from 250 to 100 or even to 50 grammes when the diet contains 350 grammes of carbohydrate The amount of protein has remained unchanged at 70 to 100 grammes

The problem of treating a patient with diabetes is still not an easy one as patients of all ages develop the disease and have very different dietetic requirements Few doubt that the general health of all patients is benefited by the giving of insulin and a well balanced diet, but many older patients refuse to have it If they are fat, diet alone may be tried with advantage, but if they are thin insulin should always be recommended It is therefore neces sary to consider other forms of treatment

The Under-nutrition Diet This consists of giving a diet of very little food value, i e tea, coffee with a little milk, gravy soup, lemonade, and plenty of water The fast used to be maintained until the glycosuria disappeared but nowadays is usually broken after one or two days irrespective of whether the glycosuria has gone or not The diet used to be increased gradually so that 10 days might elapse before it contained 100 grammes of carbohydrate Nowadays a diet containing this amount is often given at once

The diet is usually chosen in an arbitrary manner, but it can be calculated in the following manner and is then called a *main tenance* diet as it is sufficient for the basal needs of the body

The figures for the basal needs of young children and adolescents are given in a table (p 50) Those for adults are obtained from

[1] SANSUM W D BLATHERWICK, W R, BOWDEN, R (1926) *Amer J Med Assoc* 86, 178

the Boothby and Sandiford nomograph, p 48 An approximate result can be obtained by multiplying the patient's weight by 11·3 Thus an adult who weighs 132 lb will require 132 × 11·3 = 1491 Calories, and this is divided between the protein carbohydrate, and fat in the following way

The amount of protein is first settled
An adult requires about 0·5 grammes of protein per 1 lb of body weight
A child of 12 " 1·0 grammes " 1 lb " "
" " " 6 " 1·5 grammes " 1 lb "
" " " 2 " 2·0 grammes 1 lb

An adult weighing 132 lb should be given 66 grammes of protein and this figure multiplied by 4·1 (the caloric value of protein) gives 270·6 Calories and leaves 1221 for the carbohydrate and fat The amount of carbohydrate should not be less than 100 grammes This figure multiplied by 4·1 = 410 Calories 1221 minus 410 leaves 811 Calories for the fat This figure divided by 9·3, the caloric value of fat gives 87·2 grammes for the fat of the diet The diet is then prescribed as carbohydrate 100 grammes protein 66 grammes fat 87 grammes Calories 1497 This diet is divided into four meals of approximately the following amounts break fast lunch, and dinner C 30 grammes, P 21 grammes F 27 grammes Cal 460, tea, C 10 grammes, P 3 grammes F 6 grammes Cal 109

A sample diet (p 588) shows one way in which a diet containing 100 grammes of carbohydrate, 48 grammes of protein and 53 grammes of fat Calories 1093 can be arranged The amounts of protein and fat are rather less than in the basal diet and so continue the process of undernutrition The amounts of carbohydrate taken at each meal should be kept as constant as possible though the amount of protein and fat need not be so accurate The diet should be varied as much as possible and the food tables (pp 593–5) which are very simple make it easy to do this The diet contains twenty 5-gramme portions of carbohydrate and about seven 7 grammes protein—5 grammes fat portions with the addition of half an ounce of butter and these can be varied at will If it is desired to increase this diet to that necessary for the basal needs of the patient weighing 132 lb three 7 gramme protein—5 gramme fat portions with the addition of two thirds of an ounce of butter, i e 21 grammes protein and 35 grammes fat should be added to the diet

When a patient with a mild diabetes is given such a diet the glycosuria may disappear and if so the amount of the carbohydrate should be increased by 10 grammes every three or four days until a diet of 130 or 150 grammes is reached, provided that the urine

passed after the evening meal is sugar free The amount of protein and fat may also be increased A diet containing 150 grammes of carbohydrate, 73 4 grammes protein and 97 4 grammes fat Calories 1814, is set out on p 590

EXAMPLE 1 [1]

DIET FOR AN ADULT—

	C	P	F	Cal	C	P	F	Cal
Breakfast								
1 oz bread or toast	15 0	2 4	0 3	70				
2 5 gm portions of fruit or ½ oz jam	10 0	—	—	41	25 0	2 4	0 3	111
Midday Meal								
Gravy Soup	Negligible food value							
[illegible] oz meat or 2 oz white fish and ¼ oz butter	—	14 0	14 0	188				
6 oz green vegetables	Negligible food value							
¾ oz cheese	—	6 7	8 2	105				
Two 5 gm portions of fruit	10 0	—	—	41				
1 oz bread	15 0	2 4	0 3	70	25 0	23 1	22 5	404
Tea								
1 oz bread	15 0	2 4	0 3	70	15 0	2 4	0 3	70
Dinner								
Gravy soup	Negligible food value							
2 oz meat or 2 oz white fish and ½ oz butter	—	14 0	14 0	188				
2 oz potatoes	10 0	—	—	41				
[illegible] oz green vegetables	Negligible food value							
1 oz bread	15 0	2 4	0 3	70				
One 5 gm portion of fruit	5 0	—	—	21	30 0	16 4	14 3	320
3½ oz milk in the day	—	—	—	—	5 0	3 7	3 5	68
½ oz butter in the day	—	—	—	—	—	—	12 5	120
	Totals				100 0	48 0	53 4	1093

[1] Reprinted, with the permission of the Publishers from *An Index of Treatment*

If, however the glycosuria reappears after a few days with a diet of 100 grammes carbohydrate, the amount of carbohydrate should not be reduced below 100 grammes as this amount seems to be necessary for the correct metabolism of the fat, if 80 grammes only are taken ketone bodies usually appear in the urine The effect of another fast day can be tried but the patient should be advised to start insulin and have a good diet containing 130–150 or more grammes of carbohydrate

Many elderly patients with small appetites do not want to eat more than 130 grammes but the middle aged usually prefer 150–170 grammes, while the younger people should have over 200 grammes and some take 300 grammes or over The amount of fat given under these conditions varies according to the views of different workers Some give 150 grammes or more, whereas most restrict the fat to 100 grammes or so and a few insist that if the carbohydrate is raised to over 200 grammes that the fat should be reduced and believe that it should be as low as 50 grammes There are advantages and disadvantages of this diet the amount of carbohydrate is so great that a difference of 20 or 30 grammes is negligible and it is unnecessary to weigh the carbohydrate foods accurately, but the amount of fat is so small that many people feel the deprivation either of fatty foods like bacon, which they like, or if they eat bacon they miss the butter

At present it is not possible to say which is the best diet, but we would put the outside limits as follows C 150 grammes P 70–100 grammes F 100 grammes, Calories 1810–1930, and C 250–350 grammes, P 70–100 grammes, F 50 grammes Calories 1745–2265

Diets for children and adolescents are a little more difficult to arrange as they require more food than adults to enable them to grow and develop properly The number of Calories required by children is shown on p 50 and the amount of protein on p 587, and these figures are of use in arranging the diets It is suggested that those over the age of 12 should be given about 60 per cent of the caloric allowance for full activities The initial diet should contain 150 grammes of carbohydrate and the full diet for an adult, Example 2 can be used When the patients begin to take exercise the carbohydrate must be increased and the protein raised to 1 gramme per lb of body weight Children about 12 can also be started on the same diet and the diet increased later but the final requirements should be about 66 per cent of the full values

Children of about 6 weighing 3 stone need 1550 Calories for their full activity and it is suggested that the initial diet should contain 70 per cent of this amount i e 1080 Calories The diet

Example 2

High carbohydrate Diet—

	C	P	F	Cal	C	P	F	Cal
Breakfast								
1 egg	—	6 4	5 7	80				
1 oz bacon	—	5 1	15 0	160				
1 oz bread or toast	15 0	2 4	0 3	70				
Two 5 gm portions of fruit say 4 oz apples	10 0	—	—	41				
½ oz ordinary jam or marmalade	10 2	—	—	41	35 0	13 9	21 0	392
1 a m								
½ oz biscuit	—	—	—	—	10·0	1 6	0 2	48
Midday meal								
Gravy soup	Negligible food value							
3 oz meat (or 3 oz salmon)	—	21 0	21 0	282				
3 oz potatoes	15 0	—	—	61				
6 oz green vegetables	Negligible food value							
Two 5 gm portions of fruit 4 oz orange	10 0	—	—	41				
1 oz bread	15 0	2 4	0 3	70	40 0	23 4	21 3	454
Tea								
½ oz bread	—	—	—	—	10 0	1 6	0 2	48
Evening meal								
Gravy soup	Negligible food value							
2 oz meat (or 2 oz white fish and ½ oz butter)	—	14 0	14 0	188				
3 oz potatoes	15 0	—	—	61				
6 oz green vegetables	Negligible food value							
1 oz bread	15 0	2 4	0 3	70				
¾ oz cheese	—	6 7	8 2	105				
Two 5 gm portions of fruit or ½ oz cheese biscuit	10 0	1 6	0 2	48	40·0	24 7	22 7	472
11 p m								
¼ oz biscuit	5 0	0 8	—	24				
3½ oz milk	5 0	3 7	3 5	68	10 0	4 5	3 5	92
In the whole day								
3½ oz milk	—	—	—	—	5·0	3 7	3 5	68
1 oz butter	—	—	—	—	—	—	25 0	240
	Totals				150 0	73 4	97 4	1814

is determined in the following way The protein should be 68 grammes allowing 1.5 grammes per lb of body weight The carbohydrate should be at least 100 grammes These two account for 689 Calories leaving 1085 — 689 = 396 Calories for the fat This number divided by 9.3 the caloric value of fat, gives 43 grammes for the fat ration This diet is then prescribed as C 100, P 68, F 43 Cal 1085 The example below shows one way in which approximately this amount of food can be divided to make a palatable diet The amount of fat is slightly higher than in the calculation If it is desired to give the exact amount of fat some of the whole milk must be exchanged for skimmed milk

EXAMPLE 3

DIET FOR CHILD OF SIX—

	C.	P	F	Cal	C	P	F	Cal
Breakfast :								
3½ oz. milk	5.0	3.7	3.5	68				
1 egg	—	6.4	5.7	80				
1 oz. bread	15.0	2.4	0.3	70				
Two 5 gm portions of fruit	10.0	—	—	41				
					30.0	12.5	9.5	259
First Drink :								
3½ oz milk					5.0	3.7	3.5	68
Mid-day Meal								
2 oz meat	—	14.0	14.0	187				
2 oz potatoes	10.0	—	—	41				
6 oz green vegetables	Negligible food value							
⅜ oz rice	10.0	—	—	41				
3½ oz milk	5.0	3.7	3.5	68				
1 oz bread	15.0	2.4	0.3	70				
					40.0	20.1	17.8	407
Tea								
3 oz white fish	—	21.0	—	86				
1 oz bread	15.0	2.4	0.3	70				
3½ oz milk	5.0	3.7	3.5	68				
					20.0	27.1	3.8	224
Second Drink								
3½ oz milk					5.0	3.7	3.5	68
⅓ oz butter in the day					—	—	9.0	84
			Totals		100.0	67.1	47.1	1110

A child of [redacted] years weighing 26 lb requires 1150 Calories for his full activities and it is suggested that he should have 75 per cent of this amount, i e 860 Calories The amount of carbohydrate is settled arbitrarily at 80 grammes which provides 328 Calories The amount of protein required is also settled arbitrarily at 50 grammes, 2 grammes per lb of body weight This provides 205 Calories and leaves 860 — 533 = 327 for the fat This figure divided by the Caloric value of fat 9 3 gives 35 grammes for the fat ration The diet is then prescribed as C 80, P 50, F 35 The example given below shows one way in which approximately this amount of food can be arranged

EXAMPLE 4

DIET FOR CHILD OF TWO—

	C	P	F	Cal	C	P	F	Cal
Breakfast								
6 oz milk	8 5	6 3	6 0	116				
1 oz bread	15 0	2 4	0 3	70				
1 egg	—	6 4	5 7	80	23 5	15 1	12 0	266
First Drink								
6 oz milk					8 5	6 3	6 0	116
Mid day Meal								
1 oz meat	—	7 0	7 0	93				
1 oz potatoes	5 0	—	—	20				
8 oz green vegetables	Negligible food value							
⅔ oz rice	10 0	—	—	41				
3½ oz milk	5 0	3 7	3 5	68	20 0	10 7	10 5	222
Tea								
6 oz milk	8 5	6 3	6 0	116				
1 oz fish	—	6 0	—	25				
1 oz bread	15 0	2 4	0 3	70	23 5	14 7	6 3	211
Second Drink								
6 oz milk					8 5	6 3	6 0	116
	Totals				84 0	53 1	40 8	931

Patients and especially young ones should be allowed to choose which amount of carbohydrate and fat they want and the dose of insulin adjusted to meet these demands, otherwise they will pro

bably take the food they want after leaving hospital and thus upset the balance of the food and insulin

The proof of a pudding is in the eating and if the patient is not having enough food he will either remain underweight or lose weight If this is the case the amount of the carbohydrate should be increased and sufficient insulin given to control the glycosuria

Food Tables Diet formulæ appear formidable to anyone who is not accustomed to think about the constituents of the diet, but the food tables which are now in use make it very easy to choose a diet of approximately the right amount The different articles of food which are in common use are included in the following tables [1]

Carbohydrate containing Foods

Five grammes carbohydrate are contained in the undermentioned weights of the edible parts of the various foods any one item, therefore may be substituted for any other without risk of serious error The vegetables are cooked unless otherwise stated Each portion provides about 20 Calories

The carbohydrate food tables Table I, show the amount of food which contains 5 grammes carbohydrate and are arranged in four classes (a) The vegetables are divided into two groups Group I includes those which contain so little carbohydrate that they need not be weighed or taken into consideration Group II includes those which contain enough carbohydrate to make it necessary to weigh the article of food (b) The fruits are arranged in one table Most of them contain little carbohydrate and two 5 gramme portions make an average helping (c) The nuts (d) The starchy foods These are rich in carbohydrate and should be carefully weighed.

Table I—Carbohydrate

The following articles of food contain approximately 5 grammes of carbohydrate and may be substituted for each other without causing serious error

Group I—These vegetables contain so little carbohydrate that they need not be weighed

	oz		oz
Asparagus	16	Mustard and Cress	20
Brussels sprouts	10	Onions	6
Cabbage	18	Radishes	6½
Cauliflower	15	Rhubarb	18
Celery (raw)	14	Sea kale	29
Cucumber (raw)	9½	Spinach	13
French beans	16	Turnips	7
Lettuce (raw)	9½	Watercress (raw)	25
Marrow	13		

[1] The food values are calculated from the tables given in the Medical Research Council's Food Tables

How to Use the Food Tables Intelligent patients soon learn to arrange a diet and vary it so that it is not monotonous If the patient finds difficulty in doing so, the diet can be ordered as so many carbohydrate and protein fat rations Thus a diet of 100 grammes carbohydrate, 66 grammes protein, and 84 grammes fat, can be ordered as twenty 5 gramme carbohydrate (Table I) and nine protein fat rations (Table II) The nine protein fat rations contain 45 grammes fat and the remaining 39 grammes are supplied by 1¼ oz butter The three principal meals of the day should be about equal and contain 6 carbohydrate rations and 3 protein fat rations leaving 2 carbohydrate rations for tea If the carbohydrate ration is increased by 30 grammes, two 5 gramme rations are added to the three principal meals If the protein fat ration is insufficient it is better to add one protein fat ration, i e 7 grammes protein and 5 grammes fat, to the midday and evening meals

One of the remarkable points in view of what is said on page 52 about the standard caloric value of 3000 for a man is the smallness of the caloric value recommended in all these diets The modern diabetic patient is well regains the weight which he lost and maintains it In some cases the patient actually gains too much weight and it is necessary to reduce the diet once more Children, moreover also grow and develop properly on diets containing less than 2000 calories and it was remarkable that most of them did so on the old diets containing 50 grammes of carbohydrate in use before 1930 though some of them have not grown much The girls usually pass through puberty all right though some who have had a high carbohydrate diet for years fail to do so, whereas others did so on the low carbohydrate ones

In a few cases it is necessary to increase both the protein and the fat to over 100 grammes before the patient gains weight, though it is rare that more than 2400 calories are needed

The Arrangement of the Diet with and without Insulin If no insulin is given a diet containing *100 grammes carbohydrate* should be divided between four meals in equal amounts, thus Breakfast 25 grammes Lunch 25 grammes, Tea 25 grammes, and Dinner 25 grammes

If one dose of insulin is given in the morning the proportion should be Breakfast 35 grammes Lunch 30 grammes Tea 15 grammes Dinner 20 grammes

The insulin is usually given half an hour before breakfast and half an hour before the evening meal The balance of a diet of 150 grammes of carbohydrate should be Breakfast 45 grammes, Lunch 45 grammes, Tea 15 grammes, and Dinner 45 grammes

If a diet of 200 or 250 grammes of carbohydrate is given, the same balance between the meals should be maintained

If patients are liable to have an overdose, before lunch and before midnight "buffer" meals should be given—thus with a 150 gramme carbohydrate diet Breakfast 40 grammes, "Buffer" 10 grammes Lunch 40 grammes Tea 15 grammes, Dinner 35 grammes "Buffer" 10 grammes, or with a diet of 210 grammes carbohydrate Breakfast 60 grammes, "Buffer" 15 grammes Lunch 55 grammes, Tea 15 grammes Dinner 60 grammes "Buffer" 15 grammes

With the Slow acting Insulins. The action of these is slow so that the carbohydrate eaten early in the day must be reduced and that eaten later in the day increased If two doses of protamine insulin (Delay) are used the dicet should be arranged as follows

C 150 grammes Breakfast 30 grammes Lunch 45 grammes Tea 30 grammes Dinner 45 grammes

C 200 grammes Breakfast 40 grammes Lunch 55 grammes Tea 40 grammes Dinner 65 grammes

If each dose of protamine insulin (Delay) is mixed with soluble insulin the diet should be arranged as follows

C 150 grammes Breakfast 30 grammes "Buffer" 10 grammes Lunch 30 grammes Tea 30 grammes, Dinner 40 grammes "Buffer" 10 grammes

C 200 grammes Breakfast 45 grammes "Buffer" 10 grammes Lunch 45 grammes Tea 40 grammes Dinner 50 grammes Buffer 10 grammes

If one dose of protamine or globin zinc insulin is given which have a slower action than protamine the carbohydrate in the earlier part of the day must be still more reduced and a "buffer" added before breakfast thus

C 150 grammes With insulin 10 grammes Breakfast [illegible] grammes Lunch 25 grammes Tea 30 grammes Dinner 50 grammes Buffer 10 grammes

C 200 grammes With insulin 15 grammes Breakfast 35 grammes Lunch 35 grammes Tea 40 grammes Dinner 60 grammes Buffer 15 grammes

If a mixture of soluble and protamine zinc insulin is given in one dose the breakfast must be increased

C 150 grammes With insulin 10 grammes Breakfast 30 grammes Buffer 10 grammes Lunch [illegible] grammes Tea 30 grammes Dinner 30 grammes Buffer 10 grammes

C 200 grammes With insulin 15 grammes Breakfast 45 grammes 'Buffer 10 grammes, Lunch 45 grammes Tea 30 grammes Dinner 45 grammes 'Buffer 10 grammes

It must be remembered that patients vary very much in their reaction to insulin and the balance of the diets suggested should be changed according to circumstances

The dose of insulin may be small, 5 to 10 units given once or twice a day, but may be large, 50, 100 200 units and it is rare for a patient to require more than this amount each day In emergencies much larger doses may be necessary in order to save life e g 500–1000 units or more

So-called Diabetic Foods Before the discovery of insulin, these foods, especially bread and biscuits, were of some value to the diabetic Some which contained little or no carbohydrate were of especial value, but unfortunately were often unpalatable Others which still contained a considerable amount of starch together with an increased quantity of protein and fat were less unpalatable, but often caused the glycosuria to persist Fortunately, with the discovery of insulin, and the introduction of the high carbohydrate diet they are no longer used for the patients who are taking insulin Unfortunately many elderly patients dislike the thought of a daily injection and prefer to eat an unpalatable diet The so called diabetic breads and biscuits are of value until the patients suffer so much from their ill health that they are persuaded to start insulin and to eat palatable foods once more The following is a list of some of the foods on the market in 1939 [1]

	Starch per cent	Protein per cent	Fat per cent
	BREAD		
Callard s—			
Seven types varying from	0–4 75	33 6–78 2	0–12 1
Cheltine—			
Five types, varying from	28 6–35 0	[illegible]8–30 3	2 0–2 8
Energen	45	36	5 7
Heudebert—			
Six types varying from	0 8–62 94	19 0–77 2	0 69–0 83
Procea	37	20	5 0
Profarin	17 6	30 0	trace
	BISCUITS		
Allsoy	0 7	32 8	39·4
Callard s—			
Sixteen types varying from	0–2 87	21 5–72	11 8–56

[1] Some of these products may be unobtainable

BISCUITS—*continued*

	Starch per cent	Protein per cent	Fat per cent
Cheltine—			
Ten types varying from	20–52 2	25–52	9 5–20 8
Heudebert	62 94	19 90	6 83
Huntley & Palmer (Akoll)	trace	67 8	32 5
Profarin—			
Two types		30 8–40 0	tr –24 6

CAKES

	Starch per cent	Protein per cent	Fat per cent
Callard s—			
Six types varying from	0–3 0	11 5–20 7	11–33
Heudebert—			
(Chocolate Batons and Croquettes)	19 03	—	31 28

FLOUR

	Starch per cent	Protein per cent	Fat per cent
Allen & Hanbury s	1·0	82 0	1 0
Callard s—			
Nine types varying from	0–3 5	0–77	0 3–70 2
Cheltine—			
Six types varying from	15–58	28–62 5	1 5–13 5
Heudebert	26 15	50 93	2 45
Profarin	nil	63·4	nil

The reader should consult:

(1) JOSLIN E P (1910) *The Treatment of Diabetes*
(2) LAWRENCE R D (1914) *The Diabetic Life*
(3) ABRAHAMS M and WIDDOWSON E M (1937) *Modern Dietary Treatment*
(4) GRAHAM G (1910), *Index of Treatment* Hutchison & Hilton

CHAPTER XXII

THE PRINCIPLES OF FEEDING IN DISEASE

(continued)

THE DIETETIC TREATMENT OF OBESITY

The occurrence of obesity is an indication of a disproportion between the intake of potential energy in the form of food and the output of actual energy in the form of work. Sometimes the fault lies in an unduly large income, sometimes in too small an expenditure, not unfrequently both factors co operate.

The popular belief that an individual is fat because he is a large eater may or may not be true. Some patients are fat because they eat large amounts of food and take little exercise, others, although they eat ordinary amounts and take moderate exercise, and others again although they eat very little food and take much exercise. The *common factor producing obesity is the eating of more food than* the patient needs. To use more scientific language the caloric requirements of patients vary enormously. The youth of 18 who is doing military training needs 4200 Calories. The man of 21 doing similar work needs 3600. The same man doing sedentary work needs 2500–3000 Calories, while if he is in bed *only 2000 Calories*. *In the last three instances the basal metabolism is sup*posed to be the same but the normal limits of variation in the basal metabolic rate are from − 10 per cent to + 10 per cent. Thus a man whose basal metabolic rate is + 10 would need 2200 while in bed, while if the basal metabolic rate was − 10 he would need only 1800 Calories. If the basal metabolic rate were *− 40 per cent, as is the case in myxœdema only 1340 Calories* would be required, while if the basal metabolic rate were + 40 per cent as is often the case in toxic goitre 2666 calories would be necessary to maintain weight. These instances show that the needs of the body vary widely and explain the great majority of cases of obesity. Some, however, are not readily explained. Thus *Rubner*[1] *compared*

[1] RUBNER. (1902) *Beitrage zur Ernahrung im Knabenalter*. Berlin.

the metabolism of a fat boy aged 10 and weighing 41 kilogrammes with that of his thin brother, who was a year older and only weighed 26 kilogrammes The fat boy took 131 more Calories but as he was so big the Calories per square metre of body surface were approximately equal, while the Calories per kilogramme were about 8 less for the fat boy than the thin one This experiment shows that the big frame requires more food than the small one once the condition is established

Treatment of Obesity The best-known system is that described by William Banting in 1863[1] (the verb to bant has now passed into the English language) He suffered from an extreme degree of obesity, so great he tells us, as to render him unable to tie his shoe strings, and to compel him to go downstairs backwards He was 62 lb overweight at the age of 66 and lost 52 of these in the next year The diet consisted of

BREAKFAST

4 to 5 oz. of beef, mutton kidneys broiled fish bacon or any cold meat except pork a large cup of plain tea, and a little biscuit or 1 oz. of toast

DINNER.

5 to 6 oz. of any lean meat or fish any vegetable except potatoes 1 oz. of dry toast some fruit out of a pudding any kind of poultry or game and 2 to 3 glasses of good claret sherry or madeira

TEA

2 to 3 oz. of fruit a rusk or two and a cup of plain tea

SUPPER

3 to 4 oz. of meat or fish as at dinner and a glass or two of claret

For a "night-cap" he was allowed a tumbler of "grog" without sugar, or a glass or two of claret or sherry

On this regimen Banting lost 35 lb of weight in thirty eight weeks, which is not surprising, considering that his diet hitherto had consisted of bread and milk for breakfast, or a cup of tea with plenty of sugar and milk and buttered toast, meat beer, much bread (of which he was always very fond), and pastry, for dinner, a tea of the same composition as breakfast and a fruit tart or bread and milk for supper He found sugar the most fattening of all foods, 5 oz of it in a week causing his weight to rise 1 lb and he calls milk sugar, beer and butter "human beans" because they have the same effect in the human subject that beans have in

[1] BANTING, WILLIAM A letter on corpulence addressed to the Public London 1863

the case of the horse, and he regards these articles as "the most insidious enemy an elderly man with a tendency to corpulency can possess, though eminently friendly to youth" He adds "I can conscientiously assert that I never lived so well as under the new plan of dietary"

The approximate value of this diet excluding the alcohol is carbohydrate 80 grammes, protein 84–105 grammes and fat 80–100 grammes, Calories 1480–1650 The calorie value of this diet is considerably less than that required by a healthy man lying in bed, i e 2000, and Banting was up and about, the carbohydrate portion is very small, the fat ration somewhat reduced while the protein at 84–105 grammes is less than that which Voit allowed for the Bavarian peasant, 120 grammes, but is more than the average individual eats Most patients lose weight on this and similar diets but many complain of feeling limp and tired, and abandon all dieting as being too unpleasant These complaints were difficult to understand until the introduction of insulin by Frederick Banting and Charles Best in 1921 We now know that these symptoms are due to hypoglycæmia and are a sign that the diet is deficient in carbohydrate for a patient who produces a normal amount of insulin Experience shows that the amount of carbohydrate necessary to prevent the feeling of hunger and limpness is 100 grammes or more and varies between 125 and 150 grammes in individual cases This amount of carbohydrate thus supplies from 410 to 615 Calories

The value of protein and fat for the body is very different The obese patient already has large stores of fat deposited in his body and the object of treatment is to make him use these and so free his organs and depots The amount of fat in the diet should therefore be as small as is compatible with the pleasures of the table It is possible to reduce the amount of fat to 50 grammes without causing much deprivation but even this amount yields 465 Calories If the patient is obese and much overweight the fat can be reduced to 28 or 16 grammes, but these diets are definitely unpalatable and must be specially prepared The patient who really wants to lose weight can learn to adapt himself to these restrictions Protein is essential for the repair of the body but it is unnecessary to give the large amounts of 80 to 105 grammes recommended by Banting Chittenden found that he and his laboratory workers and active students maintained nitrogenous equilibrium on 55 grammes of protein but many workers prefer to give more protein and so make use of the specific dynamic action of the protein

The chief difficulty in causing a patient to lose weight is to decide

how much to reduce the calorie value of the diet It is suggested that a diet containing carbohydrate 130 grammes protein 52·0 grammes, fat 51·0 grammes Calories 1205, is a suitable one for the

DIET I

	Carbo-hydrate	Protein	Fat.	Calories.
BREAKFAST				
1 Egg	—	6·8	7·0	92
2 oz. Bread	30	4·8	0·6	140
Two 5-gramme portions of Fruit say 4 oz Apple	10	—	—	41
½ oz. Jam or Marmalade	10	—	—	41
MIDDAY MEAL.				
2 oz. Lean Meat	—	14·0	10·0	150
3 oz. Potatoes	15	—	—	61
Green Vegetables to taste		Negligible		
1 oz Bread	15	2·4	0·3	70
TEA.				
1 oz Bread	15	2·4	0·3	70
Lettuce and medium-sized Tomato if desired		Negligible		
EVENING MEAL.				
3 oz steamed white Fish	—	15·0	—	66
3 oz. Potatoes	15	—	—	61
Two 5-gramme portions of Fruit, say 4 oz Orange	10	—	—	41
8 oz Milk in the day	10	7·2	8·8	152
1 oz. Butter in the day	—	—	24·0	220
600 I.U. of vitamin D should be given each day	130	52·6	51·0	1205

This diet contains twenty-six 5-gramme carbohydrate portions and seven 7 gramme protein—5 gramme fat portions with the addition of ½ oz of butter The diet should be varied with the aid of the Food Tables The egg may be omitted from the breakfast meal and the equivalent amount of protein and fat taken at the midday or evening meal

initial treatment It gives a fair variety and can be taken by an intelligent patient who has some of his meals away from home Diet I provides plenty of green vegetables, either cooked or raw, and fruit and would contain an adequate amount of the vitamins

Diet II

	Carbo hydrate	Protein	Fat	Calories.
Breakfast				
Tea with Lemon	—	—	—	—
1½ oz Bread	22 5	3 6	0 4	105
Two [illegible] gramme portions of Fruit, say 4 oz Orange	10 0	—	—	[illegible]
Mid morning				
Unsweetened Lemonade or Marmite	—	—	—	—
Medium sized Tomato and Lettuce		Negligible		
Bran Biscuits	—	—	—	—
Two 5-gramme portions of Fruit say 4 oz Apple	10 0	—	—	41
Midday Meal.				
3 oz Meat (lean)		21 0	15 0	225
Green Vegetables		Negligible		
Three 5-gramme portions of Fruit say 3½ oz Grapefruit and 2 oz Prunes (or 3 oz Tinned Pears Peaches or Apricots)	15 0	—	—	61
Food valueless Jelly	—	—	—	—
Tea				
Tea with Lemon	—	—	—	—
1 oz Bread	15 0	2 4	0 3	70
Medium sized Tomato and Lettuce		Negligible		
Supper				
3 oz steamed white fish	—	15	—	[illegible]
2 oz potatoes	10 0	—	—	41
Green vegetables to taste	—	Negligible		—
Four 5-gramme portions of Fruit say 8 oz Orange	20 0	—	—	[illegible]
Bran Biscuits	—	—	—	—
¼ oz Butter in the day	—	—	6 0	55
750 I U of vitamin D should be given each day	102 5	42·0	21 7	787

This diet contains twenty and a half 5-gramme carbohydrate portions and five 7 gramme protein—5 gramme fat portions The diet should be varied with the aid of the Food Tables pp 593–5

DIET III

	Carbohydrate	Protein	Fat	Calories
BREAKFAST				
Tea with Lemon	—	—	—	—
1 oz. Bread	15·0	2·4	0·3	70
½ oz Jam	5·0	—	—	20
MIDDAY MEAL				
3 oz Meat (lean)	—	21·0	15·0	225
or		or		
4 oz. White Fish		20·0	—	85
Green Vegetables	—	—	—	—
Two 5 gramme portions of Fruit say 4 oz Apple or 4 oz. Pear	10·0	—	—	41
Food valueless Jelly	—	—	—	—
TEA				
Tea with Lemon	—	—	—	—
½ oz Biscuit	10·0	1·6	0·2	46
Lettuce	—	—	—	—
SUPPER				
10 gramme Cocoa	6·4	1·1	0·7	39
1 Egg	—	6·8	7·0	92
½ oz Bread	10·0	1·6	0·2	46
Salad	—	—	—	—
Three 5 gramme portions of Fruit say 6 oz Grapefruit	15·0	—	—	61
Bran Biscuits	—	—	—	—
	71·4	34·5 or 33·5	23·4 or 8·4	601 or 502

Butter nil
1000 I U of vitamin D should be given each day
This diet contains thirteen 5 gramme carbohydrate portions and gives about four to five 7 gramme protein—5 gramme fat portions

be estimated at monthly intervals to make certain that it is not raised above + 10 per cent The indiscriminate administration of thyroid extract in doses of 2–5 grains for long periods may cause symptoms of hyperthyroidism or apparently determine the onset of glycosuria

The use of other substances which *raise the basal metabolism* has been suggested Dinitrophenol has this property but is apt to produce toxic symptoms Dodds and Pope [1] found that dinitro o cresol was more potent and less toxic than dinitrophenol Dodds and Robertson [2] found that a basal metabolic rate of + 50 per cent could be maintained with a dose of 0 5–1 milligramme per kilogramme (0 25–0 5 milligramme per lb) of body weight, but toxic symptoms were produced with bigger doses Since then fatalities have occurred with the smaller doses and its use is not recommended

Of the different sorts of *beverages* in common use, *water* and the saline mineral and table waters may be regarded as harmless, but the sweetened effervescing waters such as lemonade, ginger beer, ginger ale and tonic water should be avoided unless the sugar content of the beverage is ascertained and this amount deducted from the food allowed Tea and coffee may be freely permitted if taken with little milk and no sugar Cocoa is often forbidden, but the amount of nutriment which an ordinary cupful of it contains is so small as to be hardly appreciable In many people also it has the advantage of lessening the appetite for solid food

Alcoholic beverages should be avoided as far as possible, for alcohol is a direct sparer of fat If a small allowance is indicated because the patient is unhappy without alcohol, a dry natural wine should be selected, or its alcoholic equivalent of well matured spirit freely diluted with water All strong and sweet wines liqueurs and malt liquors should be interdicted

FATTENING DIET

In the previous section we have dealt with the dietetic methods of reducing fat We have now to consider the means at our disposal for increasing it

Generally speaking, any excess of food which is supplied to the body beyond the amount required to meet the current outgoings of energy in the form of heat and work will be stored up in the form of fat One does it is true meet with cases in which, owing probably to some failure of assimilative power, it is found to be very difficult to achieve the laying on of fat, even although a considerable surplus of food is supplied, but as a rule one may say that in order to fatten the body one has merely to insure the supply of an excess of food

It will be obvious that one important means of bringing about such

[1] DODDS E C, and POPE W J (1933) *Lancet* 2, 352
[2] DODDS, E C, and ROBERTSON J D (1933) *Lancet* 2, 1137.

a surplus of income over expenditure is to diminish the outgoings of energy from the body For this reason, rest, more or less complete is always an important aid for patients whom it is wished to fatten

The diet should contain an increased amount of protein, carbohydrate and fat but respect must be paid to the likes and dislikes of the patient, since it is useless to order extra meat, etc, which the patient refuses to eat

Fat itself is the best of all fattening foods as Rubner has shown that in the formation of new fat 100 parts of fat are equal to 218 parts of carbohydrate or 313 parts of protein

It can be given in the form of cream which is easily added to various articles of diet without causing any distaste on the part of the patient Butter may be more difficult as the patient may dislike greasy cooking The fat on meat is very useful for many but unfortunately the thin people often dislike it The fish which contain fat like salmon, herring should be taken in place of white fish

Carbohydrates are very useful as extra amounts can so easily be added to the diet It is more useful than fat as a sparer of protein as it will establish a positive nitrogen equilibrium more quickly than fat does Protein is not such a good fattening agent as the other two but it is very useful in bringing a patient into nitrogenous equilibrium provided an adequate caloric value is maintained with the aid of carbohydrate and fat It will only be laid down as muscle when the muscles are either exercised or have wasted in the course of an acute disease Otherwise the amino acid groups will be split off and excreted as urea and the carbohydrate fraction will be used to lay down fat

A fattening diet is wanted in three chief sets of conditions (1) In convalescence from acute illness (2) in wasting diseases, such as tuberculosis, (3) in some nervous disorders of which neurasthenia may be regarded as the type

In *convalescence* If the high caloric diet used in the treatment of patients with typhoid fever has been used (pp 578–9) the loss of protein and fat should be very small The great demands for food due to the fever persist for three or more days after the temperature is normal and after this the diet can be gradually reduced from the [illegible] or 4000 Calories to 2500 or 3000 This can be done by omitting the extra cream and sugar which was given and adding fish and meat etc

If the old fashioned low caloric diet has been used a considerable loss of body proteins and fat will have occurred The Caloric value should be increased by the addition of cream and sugar, and the patent foods like Ovaltine, Benger's Food, Farex and Horlick s

Malted Milk are all of use Fish and eggs are added to the diet and when the patient s appetite returns, chicken and meat are appreciated Jellies, though of little food value, are agreeable to the convalescent and with custard and light milk puddings are well liked Light and moderate exercise will greatly aid the gain in weight as the patient s muscles will gradually recover their size and become firm instead of flabby

In *wasting disease* the addition of extra milk, cream, and sugar are of great value, and the principles of the diet used for typhoid fever form the basis of the treatment

In the *treatment of tuberculosis* there have been various fashions At one time it was the custom to give plenty of fat in the form of butter, bacon, pork, salad oil, and cream Patients as a rule disliked this fatty diet Later came the belief[1] that a high protein diet increased the richness and bactericidal power of the blood, stimulated leucocytosis, and replaced the waste of the muscular tissues, and diets containing 150 grammes of protein were therefore prescribed The evidence in support of this hypothesis is still lacking The modern view[2] is that the dietetics of tuberculosis demands no more than a full well balanced intake The current custom is to give diets which are high in caloric value 3000 to 4000 as for treatment of typhoid fever If the patient is very ill a fluid diet should be given The protein is usually made up to about 100–120 grammes with milk eggs, meat, or fish The carbohydrate should be about 400 grammes and the fat about 200 grammes This diet gives a Caloric value of about 4000 If a high fever is present the Caloric value should be increased if possible as the basal metabolism will be raised 7–8 per cent for each degree rise of temperature Fahrenheit (see p 576) If the patient is losing weight the Caloric value should be increased by adding to the carbohydrate or fat in the diet If he gains weight rapidly and is above the normal weight, the amount of carbohydrate and fat should be reduced

The diet should contain plenty of vitamin D, and this can be supplied by the giving of fish and fish oil, but it is usually advisable to give extra vitamins A and D in a concentrated form, at least 18,000 I U of A and 2400 I U of D should be given

Treatment of Neurasthenia

The work of Williams Mason and Wilder (see p 148), suggests that symptoms very like those of neurasthenia can be produced by

[1] Burdowell Goodbody and Chapman (1902) *Brit Med Journ* 449

[2] Keers (1944) *Lancet*, 2, 599

diets which contain very little thiamine (vitamin B_1) This may be important in the treatment of this condition An enquiry should be made into the dietetic habits of the patients

Since vitamin B_1 is widely distributed among the foods, it may be found that the total intake of food is small and the diet restricted to a few articles of food which contain little vitamin B_1 The white bread sold before the war 1939–45 contained very little B_1 (0 12–0 30 I U per gramme) but the 85 per cent and 82½ per cent National bread contained considerably more (1 2 I U per gramme) and it is claimed that the 80 per cent extracted flour contains a trifle more—1 26 I U per gramme (35 7 I U per ounce)[1] This type of bread or the wholemeal which contains about as much 0 75 to 1 3 I U per gramme, should be eaten The various meats contain 0 5 per gramme so that 1 oz contains 14 I U but pig's meat contains considerably more 62 or more I U per ounce Milk contains 130 I U per pint Thus a diet containing the following foods

	I U
8 oz. Bread 80 per cent extraction	= 285
10 oz Milk	= 65
6 oz. Meat	= 84
8 oz Potatoes	= 170
8 oz. Vegetables	= 170
	774

gives 774 I U or 2 54 milligrammes and should be adequate to prevent any symptoms of neurasthenia

If, however the patient will not take sufficient foods of this type or if the symptoms of neurasthenia exist in spite of a diet which contains an adequate amount of vitamin B_1 extra amounts should be given either in the form of Marmite, 30 I U per 1 gramme or Bemax 15 I U per 1 gramme or one of the proprietary preparations (p 696) should be given either by mouth or by subcutaneous injection Williams and Mason ended their experiments with diets containing 130–150 I U (0 4–0 45 milligrammes thiamine) by giving 1 milligramme subcutaneously followed by 3 milligrammes a day for a week and then 7 5 milligrammes for an unstated period The curative dose of a vitamin may be about 10 times the protective dose and 3000 I U or 10 milligrammes should be given for about three weeks to patients with neurasthenia This should be sufficient if a lack of vitamin B_1 is responsible for the condition

A method of treating ***neurasthenic patients*** called the Weir

[1] MORAN and DRUMMOND (1945) *Lancet* 1, 698

Mitchell Treatment or Rest Cure was once much used It consisted of giving a very high Caloric diet, and the details will be found in the 8th Edition (p 541) It is now no longer used

Anorexia Nervosa

In this condition the patient must be given a good mixed diet containing an abundance of all the vitamins The physician must gain the confidence of the patient and induce her to eat in spite of lack of appetite, nausea and abdominal discomfort A careful watch must be kept on the patient since she may vomit the food and conceal it by various subterfuges

The work by Williams Mason and Wilder on the effect of extreme deprivation of vitamin B_1 showed that in the late stages of the experiment a syndrome like anorexia nervosa developed This work suggests that big doses of vitamin B_1 should be given over and above that in the diet The dose should be greater than that given to patients with neurasthenia, i e 5400 I U a day—18 milligrammes a day This dose should be given until the patient has recovered In addition full doses of the other vitamins should be given

say, 100 milligrammes of ascorbic acid daily for four weeks	
say, vitamin A -	30 000 I U a day,
say, vitamin D	5000 I U a day,
say nicotinamide	300 milligrammes a day,
say, riboflavine	10 milligrammes a day

These amounts are necessary to make up for the lack of these various vitamins in the diet for many weeks or months The ordinary food cannot supply these amounts and the various commercial preparations (p 696) should be used

The Dietetics of Gout

The exact cause of gout is still doubtful, but it is certainly intimately associated with the metabolism and excretion of uric acid The uric acid which is excreted in the urine is derived from two sources (1) Endogenous, which is (a) derived from the breakdown of nucleins of cells, and (b) synthesized from the amino acids arising from digestion (2) Exogenous from the purines of the foodstuffs

The amount of uric acid excreted in the urine can be considerably diminished by a healthy adult if a diet is taken which contains no purines, but it can never be eliminated on account of the endogenous uric acid, which varies between 0 5 and 0 7 gramme per day The amount excreted by gouty patients varies greatly according to the state of health During an acute attack a great deal may be

excreted for a few days 0.7 to 1 gramme, but then the amount becomes normal (0.5 to 0.7 gramme) for a long or short period. The excretion, however, gradually decreases and may sink to a very small amount (0.10 to 0.20 gramme) just before an attack is due, to be again followed by a copious excretion immediately after the onset of the acute attack, and after repeated attacks the usual output may be very small, 0.20 gramme or less. It is unknown whether the small excretion is due to the combination of the uric acid with some other substance which is excreted by the kidney with difficulty, or to a direct failure of the kidney to excrete uric acid.

If extra nucleo-proteins in the form of pancreas and thymus are given to a gouty patient between attacks, the uric acid excretion is neither so prompt nor so complete as in healthy persons, and in some cases is followed by an actual decrease in the excretion. These facts explain the rationale of the low purine diet. The practice varies from the strict *Haig diet*, in which no purine-containing foods are eaten and no beverages like tea, coffee, or cocoa, because of their content of methyl purines, are drunk—to a moderate diet in which only the ***foods with a high purine content*** are barred.

THE PURINE CONTENT OF VARIOUS FOODS

	Purine Nitrogen Grammes per 100 grammes (3½ oz.)		Purine Nitrogen Grammes per 100 grammes (3½ oz.)
Herring Roe (soft)	0.484	Trout	0.092
Sweetbreads	0.426	Whiting	0.090
Whitebait	0.335	Veal	0.089
Sprats (smoked)	0.250	Mutton (leg, roast)	0.077
Sardines	0.234	Salmon	0.078
Heart	0.174	Haddock	0.072
Herring	0.172	Chicken	0.072
Mussels	0.154	Pollack	0.071
Liver	0.143	Bacon	0.069
Kidney	0.137	Pork	0.066
Bloater	0.133	Ham	0.064
Cod's Roe	0.130	Cod	0.062
Goose	0.100	Crab	0.061
Venison	0.097	Beef (sirloin, roast)	0.060
Pheasant	0.095		

(Less than 0.06 gramme of purine nitrogen per 100 grammes)

Beans	Green leaf Vegetables
Beef (corned)	Nuts
Brains	Peas
Bread	Root Vegetables
Eggs	Tripe
Flour and other cereals	

Foods Free from Purines

Butter	Jam
Cheese	Marmalade
Cream	Milk (fresh or tinned)
Fruits	Sugar
Honey	Vegetable Soups

Beverages Rich in Purines

Cocoa	Meat extracts
Coffee	Meat soups
Chocolate	Tea

Tea coffee cocoa and chocolate are usually allowed in moderation but the meat extracts and meat soups are forbidden

There are two foods soft herring roe and sweetbreads which contain over 0 400 gramme of purine nitrogen per 100 grammes of edible material, and three whitebait sprats and sardines, which contain over 0 234 gramme per cent , eight foods contain over 0 100 gramme per cent and seventeen between 0 094 and 0 050 gramme per cent The difference between these foods is often slight and partly explain the conflicting views on diet Thus whiting and veal contain 0 090 and 0 089 respectively Should these be barred while bacon, pork, and cod containing only 0 069 and 0 063 are allowed ? Or should all foods which contain more than 0 069 gramme be forbidden ?

The decision is a difficult one, and it seems better to lay down some postulates—(1) In the acute attack only foods are allowed which are free from purines (2) in convalescence from an acute attack, or if the patient is liable to frequent attacks foods are allowed which are either free from purine or contain less than 0 07 gramme per 100 grammes, (3) in the long intervals between attacks foods which contain less than 0 1 gramme per 100 grammes are allowed These restrictions do not entail any real hardship (4) In patients who have had only one attack foods containing as much as 0 150 gramme per cent may perhaps be allowed It must be remembered that 30 grammes (1 oz) of sardine or 50 grammes (1¾ oz) of kidney contain 70 milligrammes, or the same amount as 100 grammes (3½ oz) of pork or cod and could be exchanged for one another without causing any harm but the 30 grammes of sardine should not of course be taken as a savoury after the full ration of meat has been eaten Meat extracts and gravy soups are better avoided altogether as they always contain a good deal of purines Vegetable soups are allowed

The cooking of these foods is also much disputed Some recommend that the food should be plainly cooked and that all highly seasoned dishes and rich sources should be barred These instruc

tions are difficult to justify on physiological grounds unless the seasoning is done with foods which contain much purines, e g shrimp sauce These rules are probably a relic of the times before the importance of purines was recognized Similarly the recommendation that sugar and sweet things should be taken sparingly is probably due to the presence of glycosuria in some gouty patients It seems unnecessary to forbid all gouty patients to eat sugar because a few have diabetes mellitus

Beverages Tea coffee and cocoa all contain methylpurines but there is little evidence that these increase the output of uric acid in health Haig thought that they should be forbidden but nowadays they are usually allowed in moderation Alcohol *per se* is not believed to have any effect in causing gout and it is certain that gout is very uncommon among whisky drinkers On the other hand it is common among those races which drink malt liquors like beer and stout and these should be absolutely forbidden Wines present a more difficult problem Red wines like port and claret and burgundy have been responsible for causing attacks in some patients while a white wine from a neighbouring vineyard may be drunk with impunity Champagne is also regarded as a precipitating cause of gout even though other white wines and cider are safe Some patients are said to be able to take red wines in safety but to suffer from gout after drinking white wines These observations suggest that it is not the alcohol of the wine but some substance in the red or white wine to which the patient is allergic and is responsible for the tendency to gout The great majority of patients seem to be able to take white wine and cider without risk and it is on these grounds that the following table has been constructed but it must be recognized that red wines may not harm some patients while the white ones may be deleterious

Drinks to be Avoided

Red Wines	Champagne
All Malt Liquors like Beer and Stout	

Drinks Allowed

White Wines, except Champagne	
Cider	Spirits in moderation

Rheumatoid Arthritis Arthritis Osteo-arthritis and Fibrositis

A raw vegetable and fruit diet has been used for the treatment of muscular rheumatism osteo arthritis and rheumatic arthritis [1]

[1] Hare D C and Williams M B (1938) *Lancet* 1, 20 Hare D C (1936) *Proc Roy Soc Med* 30, 1

The immediate results are said to be good in a high proportion of cases but no improvement occurred in two old cases of rheumatoid arthritis The diet was

Diet I

(Daily Rations A raw diet continued for two weeks only)

	oz	
Vegetables	14	Salads Tomatoes Roots
Fruit Citrus	8	*Orange Lemon Grapefruit*
Apple	6	
Dried	4	Apricot Prune Raisins, etc
Nuts	2	Brazil Cashew Hazel etc
Oats crushed	¾	Served after soaking uncooked
Sugar	¼	One lump
Salad oil	2	Or Heinz Mayonnaise mixed with [oil
Cream, 20 per cent	3	
Milk	12	
Salt	None	
Fluids	unrestricted	Tea Water etc

Food Values (approx)

Carbohydrate	*145* grammes
Protein	*35* grammes
Fat	*143* grammes

Average Caloric value about 2000

SAMPLE MENU DIET I

BREAKFAST

Apple porridge i e —
Grated Apple
Soaked raw *Oatmeal*
Grated Nuts
Cream
Fresh Orange
Tea with milk and cream

MID MORNING

Tomato purée with lemon

DINNER

Salad Dish i e Lettuce Cabbage Tomato Roots etc Salad dressing with oil
Mixed Fruit Salad and cream

TEA

Dried Fruits
Nuts
Tea with milk and cream

SUPPER

Fruit Porridge (Prune Apricot Apple)
Salad Dish with dressing

BEDTIME

Lemon and Orange juice with hot water

DIET II

(A modified diet given for periods of several weeks)

After two weeks on the Raw Diet I the following additions were made

Cooked Foods	Vegetable soup	
	Eggs	1
	Meat	2 oz
	Bacon	2 oz
	Bread	2 oz.
Uncooked Foods	Butter	1 oz
	Cheese	1 oz
	Milk	8 oz (total milk = 20 oz)
	Salt as present in the food but no added salt	
	Oil and cream were reduced as necessary	

Food Values (approx)

Carbohydrate	146 grammes
Protein	66 grammes
Fat	142 grammes

Average Calorie value about 2200

The preparation and serving of the diets must receive close attention The green vegetables and roots are finely shredded through a special mincing machine pulped apple is prepared in the same way and mixed with a little lemon juice to prevent dis coloration Dried fruits such as apricots, prunes and raisins are soaked in water and then pulped or served whole raw oatmeal too is soaked before serving Nuts are taken whole or finely ground sprinkled over the fruit A good variety of salads and fruits should be obtained and the food daintily served This attention to detail is mentioned because it is an essential to success, other wise the food looks and tastes unappetizing and even the willing patient cannot eat it

The benefits observed in these diseases may be associated with *either the high intake of vitamin C as the patients were all in the* sub scurvy state before the treatment was started, or with the low chloride content of the diet

FIBROSITIS

Dietetic treatment is of no value

GRAVEL

This is the name given to the deposition in the urine of urates and uric acid These substances are very insoluble in an acid

intestines has taken place ascorbic acid 300 milligrammes three times a day should be given by mouth for two or four days (1800–3600 milligrammes), and thereafter a maintenance dose of 25 milligrammes a day

The diet of patients, with either a wound or fracture or who are about to undergo operations should always be enquired into and unless it is certain that the diet was adequate full doses of ascorbic acid should be given For if for some reason, the diet has been very freakish neither the wound nor bone will heal quickly, while abdominal wounds either of the stomach or skin may burst open

Dietetic Treatment of Infantile Scurvy

The treatment of infantile scurvy is purely dietetic Fresh milk contains so little vitamin C that it does not make any real difference whether the milk has been pasteurized, as it should be, or given as a dried powder Under present conditions extra vitamin C should always be given Scurvy is easily prevented by giving the juices of fruits which contain plenty of vitamin C, e g "freshly" squeezed juice of oranges, lemons, grapefruits swedes, or tomatoes are all very valuable but if the fresh juice has been standing more than half an hour it will have deteriorated considerably Fruit juice from a tin loses about half its vitamin C content in the process of preparation See Food Tables, pp 172–4

The 'war time products of rose hip syrup or blackcurrant juice and purée are very useful but the vitamin C content should be stated on the label At least 25 milligrammes ascorbic acid should be given each day In an emergency 100 milligrammes of ascorbic acid should be given for two or three days

Treatment of Rickets and Diseases due to lack of Vitamin D

Rickets is due to several factors

(1) The amount of vitamin D in the ordinary food is small Milk in the summer contributes 57 I U per pint and butter 113 I U per 1 ounce but the milk from the stall fed cow in the winter contains very little if any The yolk of an egg in the summer may give 75 I U but 22 I U only in the winter These amounts seem very small and help to explain why the disease is commoner in winter than summer

(2) Vitamin D is believed to be made as the result of exposure of the skin not only to sunlight but also to indirect light when the sun is obscured by clouds (sky shine) The smoky atmosphere of some of the northern cities prevents this effect and is probably responsible for the prevalence of rickets in those cities The

vitamin D is probably made from the sterols of the milk and other foods.

(3) A sufficiency of phosphorus and calcium must be supplied in the diet, and this will always be the case if the babies are given sufficient milk and later on cheese and an egg.

(4) Excess of cereal may be responsible and should be avoided. The use of patent foods containing much starch should be forbidden as they in some way upset the balance of the diet. Some cereals like oatmeal are more harmful than others as they contain excess of phytic acid which combines with the calcium and so prevents its absorption. Since the foods taken by babies and young children contain so little vitamin D and since they do not have the opportunity to make much vitamin D in the skin when they are brought up in large towns it is necessary to give them extra supplies of the vitamin by mouth. This is administered in the form of liver oils which contain an adequate amount of vitamin D. The vitamin content of the oil should be clearly stated on the label. The British Pharmacopœia states that 1 drachm of oil should contain at least 300 I U of vitamin D and 2000 I U of A. Cod liver oil used to have a very unpleasant taste and unless a child was given it early he would often refuse to take it later on, and few adults will face it even now that it is relatively tasteless. The best oils which are made from the liver which has been processed before decomposition of the liver has started do not have an unpleasant taste. The synthetic product calciferol should be used if the patient dislikes the oil but the cost is about ten times as great. It can be given as a tablet or dissolved in arachis oil as a liquid or in a gelatine capsule. Vitamin A is often added to its preparations (see p 701). Six drops of a good preparation usually contain 6000 I U of A and 1200 I U of D.

It is believed that the maintenance dose of vitamin D for a child of two should be at least 300–400 I U and that the curative dose is 1000–2000 units.[1] It may be much more in refractory cases.

In Older Children and Adults. Rickets may develop in young children after the age of two years if they suffer from cœliac disease. The patients pass a great deal of fat in the stool (steatorrhœa). Older patients also develop a similar disease, idiopathic steatorrhœa, and show changes in the bones similar to osteomalacia.[2] The condition is treated by ordering a diet containing the minimum amount of fat and giving vitamin D in the form of calciferol. For

[1] JEANS, P C, and STEARNS, G (1938) *Journ Amer Med Assoc* 111, 703

[2] BENNETT, T I, HUNTER, D, VAUGHAN, J (1932) *Quart J Med* 1, (25) 603

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(4) Excess of cereal may be responsible and should be avoided The use of patent foods containing much starch should be forbidden as they in some way upset the balance of the diet Some cereals like oatmeal are more harmful than others as they contain excess of phytic acid which combines with the calcium and so prevents its absorption Since the foods taken by babies and young children contain so little vitamin D and since they do not have the opportunity to make much vitamin D in the skin when they are brought up in large towns it is necessary to give them extra supplies of the vitamin by mouth This is administered in the form of liver oils which contain an adequate amount of vitamin D The vitamin content of the oil should be clearly stated on the label The British Pharmacopœia states that 1 drachm of oil should contain at least 300 I U of vitamin D and 2000 I U of A Cod liver oil used to have a very unpleasant taste and unless a child was given it early he would often refuse to take it later on and few adults will face it even now that it is relatively tasteless The best oils which are made from the liver which has been processed before decomposition of the liver has started do not have an unpleasant taste The synthetic product calciferol should be used if the patient dislikes the oil but the cost is about ten times as great It can be given as a tablet or dissolved in arachis oil as a liquid or in a gelatine capsule Vitamin A is often added to its preparations (see p 701) Six drops of a good preparation usually contain 6000 I U of A and 1200 I U of D

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[1] JEANS P C, and STEARN G (1938) *Journ Amer Med Assoc* 111, 703

[2] BENNETT T I HUNTER D VAUGHAN J (1932) *Quart J Med* 1, (25) 603

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The diet of patients with either a wound or fracture or who are about to undergo operations, should always be enquired into and unless it is certain that the diet was adequate *full doses of ascorbic acid should be given* For if, for some reason, the diet has been very freakish neither the wound nor bone will heal *quickly*, while abdominal wounds either of the stomach or skin may burst open

Dietetic Treatment of Infantile Scurvy

The treatment of infantile scurvy is purely dietetic Fresh milk contains *so little vitamin C that it does not make any real difference* whether the milk has been pasteurized as it should be, or given as a dried powder Under present conditions extra vitamin C should always be given Scurvy is easily prevented by giving the juices *of fruits which contain plenty of vitamin C*, e g "*freshly*" squeezed juice of oranges, lemons, grapefruits swedes, or tomatoes are all very valuable but if the fresh juice has been standing more than half an hour it will have deteriorated considerably Fruit juice *from a tin loses about half its vitamin C content in the process of* preparation See Food Tables pp 172–4

The 'war time' products of rose hip syrup or blackcurrant juice and purée are very useful, but the vitamin C content should be stated on the label *At least 25 milligrammes ascorbic acid* should be given each day In an emergency 100 milligrammes of ascorbic acid should be given for two or three days

Treatment of Rickets and Diseases due to lack of Vitamin D

Rickets is due to several factors

(1) The *amount* of vitamin D in the ordinary food is small Milk in the summer contributes 57 I U per pint and butter 113 I U per 1 ounce but the milk from the stall fed cow in the winter contains very little, if any The yolk of an egg in the summer may give 75 I U but 22 I U only in the winter These amounts seem very small and help to explain why the disease is commoner in winter than summer

(2) Vitamin D is believed to be made as the result of exposure of the skin not only to sunlight but also to indirect light when the sun is obscured by clouds (sky shine) The smoky atmosphere of some of the northern cities prevents this effect and is probably responsible for the prevalence of rickets in those cities The

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[1] Jeans P C and Stearn G (1938) *Journ Amer Med Assoc* **111**, 703

[2] Bennett T I Hunter D Vaughan, J (1932) *Quart J Med* **1**, (25) 603

a child 5000–10 000 I U should be given daily, but an adult may require 10 000–20 000 I U

Rickets also develops in children of 4 to 12 or older who have a chronic kidney disease of moderate severity Vitamin D is not of any value unless *sufficient* alkali is given by mouth to bring the alkali reserve within the limits of normal When this is done, vitamin D in dose of 10 000–20 000 units cures the rickets[1]

Hunger osteomalacia may occur in adults or older children as a result of long continued undernutrition with a great deficiency of vitamin D in the diet *Puerperal osteomalacia* occurs under similar conditions when the woman is pregnant Both these diseases are readily cured when the deficiencies in protein fat and calories are remedied and vitamin D in doses of 10 000–30,000 I U administered daily This treatment relieves the symptoms and heals the bones very quickly

Senile osteoporosis with fracture of the lumbar or lower thoracic vertebræ but without any of the symptoms of osteomalacia is a different disease of unknown causation A diet rich in calcium and phosphorus should be given and in addition calcium in the form of calcium phosphate 3 grammes a day and 6 grammes of sodium phosphate in the form of a powder This will provide 1 gramme of calcium and 0 6 gramme of phosphorus Vitamin D 5000–10 000 I U may be given at the same time to aid the absorption of the calcium and phosphorus from the gut but the condition does not respond quickly like osteomalacia but improves very slowly

It has been suggested that delay in the *healing of fractures* may be due to lack of vitamin D[2] This is probably the case if the patient has taken a deficient diet for some time

Very large doses 750 000 I U were given by Tumulty and Howard[4] for 10–17 days in two patients respectively *in the hopes* of healing fractures more quickly The patients developed nausea vomiting and slight albuminuria with the presence of a few red cells and casts The serum calcium rose to 16 and 18 milligrammes per 100 c c These unfavourable symptoms passed off quickly when the administration stopped *but the bones did not heal any quicker than usual* Small doses of 2000–5000 I U will aid the absorption of calcium and phosphorus from the gut and cannot do any harm

[1] GRAHAM and OAKLEY (1938) *Arch Dis Child* 1, 1

[2] BURROWS H J and GRAHAM G (1945) *Quart J Med* in the Press

[3] NELSON C F V R C (1941) *J Amer Med Ass* 181

[4] TUMULTY A V and HOWARD J F (1942) *J Amer Med Ass* 119, 233

3 *Diet in Disorders of the Stomach*

General Considerations

Seeing that the essential rôle of the stomach is a mechanical rather than a truly digestive one the physical form of the food must always be of more importance in dyspepsia than its chemical composition In proof of this one finds that so long as the stomach is able to pass the food on into the intestine absorption and nutrition go on without impairment, even although the digestive juices of the stomach itself are no longer present The first rule to be observed therefore in drawing up a dietary for disorders of the stomach is to see that the food is presented in such a form that the stomach has but little difficulty in driving it on into the duodenum In practice this means that the food must be in a fine state of division, and should be *carefully* chewed

The question of bulk must also be considered The larger the mass of the food the greater is the muscular labour imposed on the stomach It is probably on this account that animal foods are as a *class less troublesome to most dyspeptics than vegetable products* For the same reason the meals in dyspepsia should be of small size but taken at rather short intervals

As regards the behaviour of the dyspeptic stomach to the different chemical ingredients of the food, great individual differences exist and in no class of case is it more important to study the question of idiosyncrasy In a majority of instances however, one finds that fat is more apt to give offence than any other constituent This is particularly true of *cooked* fat, possibly because in process of cooking fatty acids acrolein and other irritating substances are apt to be liberated On the other hand butter and bacon fat which have a low melting point can usually be managed with but little difficulty

We may now pass to the more detailed consideration of the dietetic treatment suitable in different forms of gastric disorder, leaving the discussion of some further general principles until we come to speak of ' functional dyspepsias In handling the subject it will be well to take up first those diseases of the stomach which are accompanied by definite organic change and afterwards to consider the so called functional disorders in one group Such an arrangement is admittedly unscientific but it has the advantage of practical convenience and our knowledge does not at present admit of any more satisfactory system of classification

GASTRIC ULCER

The principle is generally accepted in cases of gastric ulcer that the work of the stomach should be as light as possible and that the food should not irritate the mucous membrane The idea of rest was carried so far at one time that no food was given by mouth and various types of nutrient enemata or water containing salt and sugar were given per rectum It is now recognized that nutrient enemata are of very little value (p 687) and they should not be used Rectal salines are of great value when the patient has lost much fluid either by vomiting, severe hæmorrhage or whenever the patient is unable for some reason to take a sufficient amount of fluid by mouth (p 685) Under these conditions a 5 per cent solution of glucose in tap water ½ normal saline, or ⅕ Ringer's Solution is of great value, and 3000 c c may be given in the day if fluid is not given by any other route (for intravenous amino acids, see p 688)

Lenhartz[1] in 1906 introduced the practice of feeding patients by mouth, starting with very small amounts of an egg and milk mixture and gradually increasing it daily The guiding principles of the diet were (1) to aid the healing of the ulcer by giving as much nourishing food as possible (2) to fix the acid of the gastric juice by ensuring that the food contains a large proportion of protein, and so prevent its interfering with healing (3) to lighten the work of the stomach as much as possible by the use of small feeds It is often found that patients may vomit after a 6 or 8 oz feed, but will not do so after 2 oz feeds given at one or two-hourly intervals The details of the modified diet in use at St Bartholomew's Hospital are as on page 625–6 Some physicians start at Diet 1 and increase the diet each day, but most of them start at Diet 4 6, or 8, according to the severity of the symptoms, and increase every one or two days If a patient has a return of pain while taking Diet 7 he is given Diet 6 or 5 for several days When all symptoms have disappeared Diet 7 is again tried and if no evil symptoms occur the diet is increased every one two, or three days The patient should be kept on Diet 12 until all the symptoms have subsided the stools do not contain any blood by chemical tests the X ray after a barium meal is normal and an ulcer cannot be seen with the gastroscope

Suggested Details for Diet 9

All liquid feeds should be 5 oz (¼ pint or a small breakfast-cupful)

[1] LENHARTZ (1907) *Med Klin* LANGDON BROWN (1908) *Clin Journ* 33, 109

One teaspoonful of sugar should be added to each food Take nothing except the foods and amounts given below

7 a.m Boiled fresh milk and water (equal parts) or dried milk watered down to half the strength given on the packet
1 Rusk or cream cracker
9 a m 1 Egg beaten up in milk
11 a m Boiled fresh milk and water (equal parts) or dried milk Benger's Food or alternatives watered down to half strength
1 Rusk or cream cracker
1 p m Boiled or steamed white fish 2 oz (3 level tablespoonfuls) White sauce or milk to moisten if desired No salt seasoning or parsley
Blancmange custard or junket 2 oz (2 level tablespoonfuls)
3 p m Boiled fresh milk and water (equal parts) or dried milk Horlick's Malted Milk or alternatives watered down to half strength
1 Rusk or cream cracker
5 p m 1 Egg beaten up in milk
1 Rusk or cream cracker
7 p m Boiled fresh milk and water (equal parts) or dried milk Ovaltine Bournvita or alternatives watered down to half strength
Blancmange or custard or junket 2 oz
9 p m 1 Egg beaten up in milk
11 p m Boiled fresh milk and water (equal parts) or dried milk watered down to half strength

During the night when awake, take 5 oz boiled fresh milk and water (equal parts) or dried milk watered down to half strength

Water up to 5 oz may be taken between any two foods and the juice of one orange well strained once in the day if allowed by the doctor

Any fruit juice like lemon grape fruit tomato blackcurrant and rose hip syrup can be taken to vary the taste of the food

Suggested Details for Diet 14

All liquid foods should be 5 oz (¼ pint or a small breakfast cupful) One teaspoonful of sugar should be added to each food Take nothing except the foods and amounts given below

7 a m. Boiled fresh milk and water (equal parts) or dried milk watered down to half the strength given on the packet
2 Buttered rusks or cream crackers
9 a m 1 Egg beaten up in milk
2 Buttered rusks or cream crackers

Feeds by Day	Food	Diets 1	Diets 2	Diets 3
1	Whole milk (fresh or dried) oz	5	5	5
	Patent barley or strained porridge	Portion	Portion	Portion
2	1 Egg beaten up in milk oz	5	5	5
	Buttered rusks or cream crackers	—	1	2
3	Whole milk (fresh or dried) oz	5	5	5
	Marmite to taste			
	Barley sugar oz	1	1	1
	Thin crustless white bread and *butter* slices	—	1	2
4	Strained orange or tomato juice oz	1	1	1
	Vegetable purée (see list)	Portion	Portion	Portion
	Pudding (see list)			
	Cream oz	1	1	1
	Boiled or steamed fish	—	—	Portion
5	1 Egg beaten up in milk oz	5	5	5
	Barley sugar oz	1	1	1
	Buttered rusks or cream crackers	—	1	2
6	Whole milk (fresh or dried) oz	5	5	5
	Fruit purée (see list)	Portion	Portion	Portion
	Pudding (see list)			
	Cream oz	—	1	1
	Thin crustless white bread and butter slices	—	1	2
7	1 Egg beaten up in milk oz	5	5	5
	Black treacle or barley sugar oz	1	1	1
	Buttered rusks or cream crackers	—	1	2
8	Whole milk (fresh or dried) oz	5	5	5
	Fruit purée (see list)	Portion	Portion	Portion
	Pudding (see list)			
Feeds at Night (when awake)	1 Whole milk (fresh or dried) oz	5	5	5
	2 1 Egg beaten up in milk oz	5	5	5
Between Feeds	Strained orange- or tomato juice oz	1	1	1
	Water up to 5 oz when desired			
	Approximate caloric value	2545	3118	3624

of milk and cream Custards cream soups vegetable purées, and other soft palatable foods may be substituted now and then for the milk-and-cream feedings Jellies and marmalades may be gradually added if desired The patient should be weighed If desired a sufficient quantity of food may be given to cause a gain of 2 or 3 lb each week

At the end of three weeks of the treatment three small meals none of which exceeds 10 to 15 oz in total bulk are substituted for three of the feeds the remainder of which are continued as before These meals are made up of vegetable purées potatoes and cooked fruits Bacon and meat broths are added

'Upon resuming normal activity or work the patient continues the same management He eats the three small meals at home or wherever it may be convenient Milk and cream mixed equal parts is taken with him to his place of business A thermos bottle is a desirable container From this supply a flat flask may be filled and carried in the pocket

Meulengracht[1] has found that patients with hæmatemesis have a lower mortality if they are given a fair amount of food very soon after the hæmatemesis Witts[2] who modified this diet to meet English tastes, has also had good results (See p 628)

Diet 1 does not differ materially in composition from the 8th Lenhartz Diet but its caloric value is much higher owing to whole milk being given instead of milk diluted with water, and to the addition of extra sugar and cream The vitamin C content is slightly higher owing to the use of the purées of vegetables and fruit instead of only orange juice The Caloric value of Diet 3, 3021 Calories seems higher than is necessary for patients doing an average amount of work though it may be indicated if the patient has lost a great deal of weight or has returned to hard work

These diets differ from the early stages of the Lenhartz Diet in that they contain in addition to the greater Caloric value much more fluid, which is of use when the patients have had a hæmatemesis The water can be added to the Lenhartz Diet in the form of quarter strength normal saline and adequate amounts should be given

Both the Lenhartz and Sippy Diets in their original form contained very little ascorbic acid as all vegetables were omitted and the *juice of oranges and lemons was forbidden because they have an acid taste*[3] It has been found (Harris and Ray[4] Archer and

[1] MEULENGRACHT (1934) *Acta Med Scand* 59 374

[2] WITTS L J (1937) *Brit Med Journ* 1 847

[3] Meulengracht's Diet contains 30–50 milligrammes of ascorbic acid

[4] HARRIS L J RAY S N and WARD A (1933) 27 2011 HARRIS L J ABBASY M A, YUDKIN K and KELLY S (1936) *Lancet* 1, 1488

Graham [1] Portnoy and Wilkinson [2] etc), that patients fed on these diets are in the sub scurvy state and the degree of deficiency is especially great when patients have suffered from a hæmatemesis Most patients have had symptoms of dyspepsia some time before they seek medical aid, and it may be assumed that they have omitted from their diet the common sources of ascorbic acid It was recommended (Archer and Graham) that 1000 milligrammes of ascorbic acid should be given each day for three days to all patients with symptoms of gastric ulcer, and for four days if a hæmatemesis has occurred Thereafter a maintenance dose of 25–50 milligrammes should be given daily either in the form of orange or lemon juice, blackcurrant purée or syrup or hip and haw syrup or as pure ascorbic acid

The after treatment is very important if the ulcer is to heal soundly Alcohol should not be allowed as it is liable to cause or keep up a gastritis The use of foods highly seasoned with mustard pepper, spices, and condiments of all kinds should be forbidden for the same reason Tea and coffee should either be forbidden or only allowed if well diluted with water or milk Cane-sugar should not be given because it causes a large secretion of mucus , glucose and lactose are said to do less harm

The smoking of all kinds of tobacco should be forbidden The evil effect of tobacco is probably due to the nicotine and its decomposition products e g pyridine, being dissolved in the saliva and so swallowed The taste of the saliva of a heavy smoker can be best appreciated by a non smoker if when working in a laboratory, he uses the distilled water wash bottle of the smoker Many patients find great difficulty in giving up smoking

Jejunal Feeding

If the ulcer is very large or heals very slowly resort may be had to jejunal feeding This is said to be better than duodenal feeding as the meal sometimes regurgitates from the duodenum into the stomach and details of jejunal feeding alone are given [3]

A soft pliable Einhorn's tube is passed into the stomach and after the tip has passed the pylorus it is pushed onwards until the tip is 32 in to 35 in from the lips The initial feeds should consist of 1 raw egg beaten up 150 c c (5 oz) milk and 15 grammes (½ oz) lactose This is strained through several layers of gauze warmed

[1] Archer H E and Graham G (1936) *Lancet* 2, 364

[2] Portnoy B, and Wilkinson J F (1938) *Brit Med Journ* 1, 553

[3] Bockus (1924) *J.A.M.A* 82, 351

to a temperature of 100° F , placed in a receiver 4 in above the upper surface of the abdomen The size of each feed is increased by 10 c c (⅓ oz) each day until 210-240 c c are administered The tube is left in position and washed through after each feed with normal saline and air Extra fluid is given on the second day in the form of 350 c c of one third normal saline twice a day and the volume is increased up to 750 c c b d 100 milligrammes ascorbic acid should be given daily

An alkaline powder consisting of magnesium oxide gr 3 bismuth subnitrate gr 15 , water to 1 oz is given by mouth between feeds and a double dose at night so as to ensure that the stomach mucosa is always alkaline

The tube is removed after two weeks and a modified Sippy diet is given for the next two weeks

MODIFIED SIPPY DIET

		8 oz Milk.
		1 Egg
	with	8 oz malted milk
4–7th day		3 oz Cooked cereal for three feeds
		Biscuits and butter
8–15th day	8 a m	2 Soft boiled eggs
		Toast and butter
		Cooked cereal
		1 glass milk
	10 a m	Egg and milk
		Biscuit and butter
	Dinner	Fish or sweetbread
		Purée of vegetables
		Mashed potatoes
		Tapioca pudding
	4 p m	Malted milk.
	Supper	Clear soup
		Poached egg
		Chicken or lamb chop
		Purée and mashed potatoes
		Bread and butter
		Cocoa and milk
	9 p m	Egg and milk

50 milligrammes ascorbic acid should be given daily

A jejunostomy is sometimes performed if patients with severe gastric diseases suffer from uncontrollable vomiting alkalosis and renal failure which cannot be controlled by intravenous therapy The patients must be fed by this route for some weeks The in dwelling catheter must be size 17 or greater

Scott and Ivy have been able to keep dogs alive and well with

the following mixture which Colp and Druckerman[1] have used with success on men

Four hours after the jejunostomy 60 c c of warm normal saline are given every 2 hours After 12 hours 60 c c (2 oz) of the Scott Ivy pabulum is given every 2 hours alternately with 60 c c (2 oz) saline The quantity of the feed is gradually increased to 120 c c (4 oz)

If the ulcer does not heal after a good trial has been given to these various measures a partial *gastrectomy should be considered*

Scott Ivy Pabulum Sugar 150 grammes water 3000 c c Add peptone 100 grammes and wait till it dissolves Heat to 60° C for a few minutes and add it to 300 grammes of wheat flour making a paste at first and then diluting it with all the peptone and sugar *Then add 2000 c c milk mixed with 1000 c c cream 20 per cent* and bring to a boil quickly, stirring vigorously but do not allow to boil Maintain just below the boiling point until it thickens to the consistency of a thick cream soup Cool and place in a refrigerator where it will keep for 4–5 days

100 c c contains	Protein	3 5	= 85 calories
	Carbohydrate	8 1	
	Fat	4 3	
	Add 10 c c emulsified bile		
Vitamins	Vitamin A	3000 I U	
	D	600 I U	
	(as Radiostoleum)	3 drops or Adexolin	
	Vitamin B_1	1000 I U	3 mg
	Riboflavine		1 mg
	Nicotinamide		50 mg
	Vitamin C		10 mg

Diets in Convalescence from Acute Dyspepsia

The series of Diets Nos 1 2 and 3 in use at St Bartholomew s Hospital are useful for convalescence, and if a patient can take Diet 3 without any symptoms he may then begin to return to an unrestricted diet He should understand that as soon as any symptoms return he should use the convalescent Diet 1, and if the symptoms continue should use a lower stage of diet, say the 6th or 8th Lenhartz Diet or Meulengracht Ist diet

Diet I Eight feeds should be taken during the day the first on waking, milk and biscuits should be taken during the night

[1] Colp R and Druckerman, L J (1943) *Ann of Surgery* 117, 387

[2] Scott H G and Ivy A C (1931) *Ann of Surgery* [illegible] 1197

whenever the patient wakes The four main meals which are given below should be equal in size The small feeds given between meals at two hourly intervals These *between feeds* should consist of ½ pint of warm boiled milk, flavoured if desired with cocoa, Bournvita Ovaltine, Marmite, Horlick's Benger s, or the like Cream crackers, rusks, or other plain biscuits, not wholemeal If the beverage and biscuits cannot be obtained one or other will suffice, and should neither be obtainable a piece of plain or milk chocolate may be eaten slowly

Water (not iced) up to ½ pint may be taken between feeds, and a small amount with meals

The well strained juice of an orange must be taken twice daily, preferably between feeds Fresh strained tomato juice may be substituted occasionally or a glass of tinned tomato juice or black currant juice or puree or hip and haw syrup In cases where fruit juices are not tolerated one or two tablets of ascorbic acid (25–50 milligrammes) may be substituted

Food should be cooked with a little salt but no other condiments

DIET II If desired the number of feeds may be reduced to seven, and the interval between them increased to two and a half hours The main meals should be somewhat bigger than the between feeds

DIET III This is an easily digested normal diet suitable for constant use by patients who have suffered from gastric or duodenal ulcer or other continued gastric disturbance The interval between meals may be increased to three or four hours, and the number reduced to four or five The main meals should be of normal medium size If the patient ought to gain weight three or four " between feeds should be given They should also be given if any discomfort is felt in the interval between meals

DIET III ADAPTED FOR ACHLORHYDRIA No between feeds should be taken Only small amounts of fluid should be taken with meals, the rest being drunk between them Each meal should be begun with a mild appetizer such as tomato orange or grape fruit juice or a small teacupful of Marmite The latter should be taken daily as a beverage or sandwich spread

DIET I

BREAKFAST

One egg lightly boiled or poached

White bread stale and crustless cut thinly or crisp toast (not hot) with butter

Honey golden syrup apple, black currant, or bramble jellies, or strained jelly marmalade
Weak tea or cocoa with plenty of milk Sugar if desired

DINNER

Fresh white fish boiled or steamed or stewed sweetbreads brains or tripe
Plain white sauce if desired
Mashed old potatoes or crustless stale white bread cut thinly or plain biscuits
Milk pudding custard junket, blancmange jelly, or plain steamed cake-mixture pudding

TEA

White bread or toast and butter as at breakfast
Honey etc as at breakfast, or Marmite
Plain sponge or Madeira cake or biscuits

SUPPER OR LUNCH

One or two eggs lightly boiled or poached or fresh cream or milk cheese
Cream crackers rusks or other plain biscuits
Warm boiled milk, if desired flavoured with cocoa Bournvita Ovaltine, Benger s Horlicks or the like
Pudding as at dinner, if desired
Interval between meals and feeds two hours

Not allowed

Beer stout whisky and other alcoholic drinks and mineral waters (except soda water)
Brown bread new white bread rolls buns porridge and digestive, wholemeal ginger coco-nut, Vitaweat or Ryvita biscuits
Coffee
Fish with fine bones such as herrings or salt fish and salmon
Fried foods of all kinds
Fruit stewed tinned or raw (except strained orange juice)
Jam peel of marmalade currants and other dried fruit nuts seeds.
Meat bacon ham sausages chicken and rabbit
Pickles and rich sauces vinegar, condiments added salt or other seasoning
Soups meat extracts and Marmite
Suet puddings and pastry
Vegetables and salads of all kinds and parsley in sauce

Smoking

DIET II

BREAKFAST

The same as in Diet I

DINNER.

As Diet I with the following additional alternatives
Boiled or roast chicken or guinea fowl (no skin or gristle) or stewed rabbit
Flower of cauliflower sieved carrots spinach peas or tomatoes
Baked or stewed apple (no skin or core) sieved stewed prunes apricots peaches or pears fresh or tinned or sieved raw bananas

TEA.

The same as Diet I

SUPPER OR LUNCH

The same as Diet I
Interval between meals and feed , two to two and a half hours

Not allowed

Beer stout whisky and other alcoholic drinks and mineral waters (except soda water)
Brown bread new white bread rolls buns porridge and digestive wholemeal ginger coco-nut Vitaweat or Ryvita biscuits
Coffee
Fish with fine bones such as herrings or salt fish and salmon
Fried foods of all kinds
Fruit (except those given above)
Jam peel of marmalade currants and other dried fruit nuts and seeds.
Meats such as bacon, beef ham sausages brawn
Pickles rich sauces vinegar and condiments except salt in small quantities
Soups meat extracts and Marmite
Suet puddings and pastry
Vegetables (except those given above) new potatoes, parsley and salads
Smoking

DIET III

BREAKFAST

As Diets I and II with the following additional alternatives
Finely ground brown bread
Fresh white fish steamed or grilled, or a second egg
The eggs may be scrambled.

DINNER.

As Diet II with the following additional alternatives
Tender lamb or mutton veal liver tongue or ham
Grapes soft ripe plums pears and peaches avoiding skin pips and stringy portions
Boiled old potatoes
Vegetables and fruit in Diet II need not be sieved.

TEA

As Diets I and II with the following additional alternatives
Finely ground brown bread
Plum or apricot jam

SUPPER OR LUNCH

As Diets I and II with the following additional alternatives
Steamed or grilled fresh white fish chicken etc *as at dinner*
Vegetables and fruit as at dinner
Interval between meals and feeds three to four hours

Not allowed

Beer stout whisky and other alcoholic drinks and mineral waters (except soda water)
Coffee
Fried foods
Fruit skins seeds *and hard fruits such as raw apple pineapple etc* dried fruits and nuts
Kippers bloaters and salmon
Meats such as beef and the tough parts of all other meats
Meat soups, meat extracts and Marmite
Pickles rich sauces vinegar and condiments except salt in moderate amounts
Suet puddings and pastry
Vegetables such as cabbage and onions also the stalks skins pips and hard fibrous parts of other vegetables

ACUTE AND CHRONIC GASTRITIS

The disease may start with vomiting and this may be so severe that even 1 oz feeds of milk are rejected In this case fluid should be given per rectum either as a 5 or 6 per cent solution of glucose in tap water or $\frac{1}{2}$ or $\frac{1}{3}$ normal physiological saline or Ringer's Solution 600 c c (1 pint) may be given 4 hourly or in the form of a continuous drip 3000 c c a day (5 pints) When the gastritis is severe it may be accompanied by an acute enteritis, which renders *the giving of fluid per rectum impossible In these cases* the fluid should be given intravenously or intramuscularly either as a continuous drip of 5 per cent glucose in $\frac{1}{2}$ or $\frac{1}{3}$ normal saline or Ringer's Solution or 600 c c may be given three to four times a day (p 687) When the acute condition either improves sufficiently for the patient to be fed by mouth or is not severe enough to cause vomiting the early stages of the Lenhartz or Sippy diets should be used It is usually possible to increase the diets much more quickly than if an ulcer is present

In the treatment of chronic gastritis the condition will usually improve quickly with the full diet allowed by Lenhartz and Sippy or Meulengracht but it may be necessary to order a diet like the

6th or 8th Lenhartz Diet When the symptoms disappear the diet can as a rule be increased more quickly than in the treatment of gastric ulcer

Alcoholic Gastritis

It is essential that all alcohol should be given up even if the patient says that alcohol is the only thing which enables him to eat a meal If vomiting is a prominent feature the patient should be in bed and small divided meals should be given, say Lenhartz Diet 8 or 10 The diet can be increased fairly quickly as soon as the ill effects of the alcohol have passed away

Dilatation of the Stomach

Complete Pyloric Obstruction When the diagnosis has been made fluid should not be given by mouth as it cannot pass the pylorus At least 3000 c c of fluid should be given either per rectum or intravenously or intramuscularly or by sternal puncture (p 685) It is essential to give large amounts of ascorbic acid as Payne[1] showed that in 12 out of 51 cases peritonitis was a serious complication after any operation on the stomach and that the wounds showed no sign of healing Archer and Graham[2] suggested that this was due to a lack of ascorbic acid They recommended that at least 3000 milligrammes should be given before any operation

The patients are usually in the sub scurvy state and it is important to give at least 3000 milligrammes of ascorbic acid If the pyloric obstruction is severe it is necessary to give it intramuscularly

If large doses of ascorbic acid are given intravenously some will be excreted in the urine and suggest that the patient was not in the sub scurvy state One of us (G G) has found that 300 milligrammes can be given intravenously twice a day without causing much loss of ascorbic acid in the urine If this amount is given for five days the risk of the wounds failing to heal is very small but it is advisable to give a daily dose of 1000 milligrammes of ascorbic acid for the first three days after the operation

Partial Obstruction It is often uncertain whether the dilatation of the stomach is due to an organic obstruction or to an atony of the walls of the stomach The food should consist of milk egg and milk or milk and cream or other substances which will pass through the pylorus easily About 200 grammes of glucose should be added to the feeds during the day Two or three ounces of the mixture should be given every one or two hours during the

[1] Payne R T (1936) *St Bart s Hosp Reports* 69, 191
[2] Archer H E and Graham G (1936) *Lancet* ii, 364

The principles to be observed in prescribing rules of diet in each of these forms may now be briefly discussed

1 *Defective Secretion* There may be no symptoms of dyspepsia in patients with hypochlorhydria or complete achlorhydria and if so dietetic regulations are not required Some of these patients have pain and discomfort immediately after the meal is taken and examination of the gastric contents and with X rays show that the stomach empties very quickly The foods should either be pounded, minced or sieved, so as to ensure the food being finely divided when it reaches the intestines In mild cases thorough mastication of the meat, etc may suffice The rapid passage of the food may be reduced or prevented by giving fatty foods with the meals, or an oil like olive or almond after the meal has started [1]

DIRECTIONS FOR DIET IN ACHLORHYDRIA

1 The diet should contain the usual amount of eggs milk cheese fish and meat (*The latter two may have to be pounded or minced*)
2 Salt, pepper mustard meat extract, marmite gravies meat soup spices pickles *condiments are allowed in normal* amounts
3 Bread potatoes are allowed
4 Orange or lemon juice 4 oz or other fresh fruit should be taken once or twice a day If these disagree 25 milligrammes of ascorbic acid should be given each day
5 Fluid should not be taken at meals though one glass of wine red or white is allowed
6 Hydrochloric acid minims 15 may be taken in 3 oz of water with the meals
7 Sufficient fluid should be taken either half an hour before meals or two hours after meals to relieve thirst or any discomfort from lack of fluid At least two to three pints of fluid should be taken daily

2 *Excessive Secretion* Much discussion has taken place as to whether the diet in cases of hypersecretion should be mainly animal or vegetable in constitution [2] On the one hand, there is no doubt that an animal diet "fixes" the excess of hydrochloric acid most efficiently whilst on the other there is abundant evidence to show that in the long run a mainly vegetable diet leads to a permanent diminution of acid formation An animal diet is therefore the best palliative, whilst a vegetable diet is more strictly

[1] MORRELL ROBERTS (1931) *Quart Journ Med* 24, 133

[2] See SCHLOSS (1907) Vegetabilische oder Fleischnahrung bei Hyperacidität (*Arch f Verdauungs Krankh* 13, 233)

curative in effect In the experience of Hutchison a predominatingly animal diet gave the best results whilst other means may be relied upon for actually lessening secretion (e g the free use of fats, administration of alkalies etc)

On the other hand, it is reasonable to exclude all direct stimulants of secretion Under this heading come such substances as common salt, extractives of meat, the various condiments, and alcoholic beverages

There is both experimental and clinical evidence[1] to show that fats have a restraining influence on gastric secretion

The evidence[1] suggests that the unsaturated oils like linseed and cod liver oil are the most effective These are unpleasant to take and olive or almond oil which are less effective are used The oil produces the greatest effect when it has entered the duodenum before the meal is taken The usual dose is one ounce

Foods rich in carbohydrates on the other hand, must be eaten sparingly, as free acid appears in the stomach very early after their use and the conversion of their starch by the saliva is interfered with For this reason the addition of malt to farinaceous foods is often of great service in cases of hyperacidity It stands to reason that where acidity of the stomach is proved all sour articles should be banished from the diet Vinegar and some wines are examples in point

The application of the above principles may be expressed in the following rules

DIRECTIONS FOR DIET IN HYPERCHLORHYDRIA

1 The diet should consist mainly of animal constituents (eggs milk cheese fish and meat)
2 Green and root vegetables may be eaten in moderation unless flatulence occurs
3 Salt pepper mustard meat extracts gravies meat soups spices pickles and condiments should be altogether avoided
4 Bread and potatoes should be taken very sparingly but bacon and butter may be eaten freely
5 Sugar and all sweet or sour things should not be eaten
6 Orange- or lemon juice 4 oz or other fresh fruit should be taken once or twice a day If these disagree 25 milligrammes of ascorbic acid should be given each day
7 Alcoholic beverages should be avoided The best drink at meals is an alkaline water such as Apollinaris or Perrier
8 One ounce of olive or almond oil should be taken 10 minutes before meals

[1] MORRELL ROBERTS (1931) *Quart Journ Med* 133

Gravy or white sauce (not containing parsley or any other vegetables)
Mashed old potatoes (No other vegetables are allowed)
Milk pudding custard blancmange junket plain jelly, or steamed cake mixture pudding (no fruit, jam etc)
Chocolate may be eaten after meals, or used as flavouring

TEA

Tea with milk and sugar to taste
White bread and butter
Honey, golden syrup black treacle jelly, cream cheese or Marmite
Sponge or plain madeira cake (no fruit peel seeds or nuts) or plain biscuits (not digestive wholemeal coco-nut Vitaweat or Ryvita)

SUPPER

Tea, coffee or cocoa made with milk or any other form of milk food Sugar to taste
White bread or plain biscuits and butter
Eggs white fish smoked haddock soft cheese or pudding
Mashed old boiled potatoes and sieved vegetables

BEDTIME

Cocoa milk or any other form of milk food Sugar to taste
Plain biscuits if desired

Well strained and sweetened orange, lemon or grapefruit juice should be taken two or three times a day

The foods may be arranged according to taste
Meals should never be eaten in a hurry and at least ten minutes rest should be taken after finishing them

Foods not allowed

All foods which leave a residue after digestion These include
Biscuits such as digestive wholemeal coco nut macaroons Vitaweat and Ryvita
Brown bread wholemeal and other varieties
Fish with small bones (eels herrings kippers bloaters and sardines)
Fried foods
Fruits stewed tinned or raw except strained orange lemon or grape fruit juice
Jams peel marmalade and dried fruits such as currants sultanas cherries etc
Meat except rabbit chicken sweetbreads brains tripe *(no onion) or* minced tender lamb
Nuts
Porridge *Shredded Wheat and all wholemeal cereals*
Salads and parsley
Vegetables (unless well sieved) except mashed old potatoes

If the diarrhœa is associated with *achylia* the diet suitable for this condition should be used (p 640) If the stools are acid in reaction the amount of starch in the diet should be reduced to a minimum ,

when the diarrhœa has ceased the carbohydrate should be cautiously increased If the stools are alkaline in reaction the smell is often very offensive Meat should be withheld but milk cheese and carbohydrates are usually well tolerated When the diarrhœa ceases fish and meat should be added gradually If the stools are very pale the condition is probably due to excess of fat steatorrhœa This occurs in cœliac disease and chronic pancreatitis (For treatment of sprue see p 647) The fat should be reduced to a very small amount Fresh skimmed milk should be obtained from a dairy (permission from the Milk Marketing Board may be necessary) or one of the dried skimmed milk products should be used The milk may be thickened with cornflour etc and flavoured with coffee or tea Gravy soups or meat extracts are useful together with starchy foods Fruit fresh or cooked is usually well tolerated but it is usually necessary to strain it White fish which contains practically no fat, and lean meat may be added later on If the patient has either cœliac disease or chronic pancreatitis he must keep to this diet for a long time and as it is deficient in vitamins 9000–15 000 I U of A and 1800–3000 I U of D should be given each day to ensure the proper absorption of calcium Extra vitamin B should be given in the form of yeast or some concentrated preparation (pp 696–9) These patients sometimes suffer from a macrocytic anæmia and either an extract of liver or hog s stomach should be given by mouth or a potent liver extract injected intramuscularly

When the patient improves extra fat may be added cautiously It is advisable to estimate the total fat lost in the stool over a period of three days so as to be certain that too much fat is not given If more than 20 grammes of fat are lost in the day the fat intake should be reduced

Low fat Diet

BREAKFAST

Tea or coffee with skimmed milk fresh condensed or dried and sugar if desired

Porridge Shredded Wheat or other breakfast cereal with skimmed milk and sugar

Bread and jam, marmalade honey golden syrup or black treacle

Smoked haddock or white fish if desired

MID MORNING

Tea or coffee with skimmed milk and sugar if desired or well sweetened lemonade

Plain water biscuits (not petit beurre etc)

DINNER

Boiled or steamed white fish or smoked haddock with skimmed milk or tomato sauce

Rabbit or tripe stewed in skimmed milk stewed liver boiled or steam chicken, or very lean meat
Potatoes boiled mashed with skimmed milk or baked in their jacket
Green or other boiled vegetables
Skimmed milk pudding or blancmange or custard powder custard mad with skimmed milk or boiled rice and jam, or jolly, or summ pudding
Fresh or stewed fruit

TEA

Tea with skimmed milk and sugar if desired
Bread and jam marmalade golden syrup honey or black treacle c sandwiches made with tomato mashed banana Marmite or mea extract instead of butter
Buns or plain water biscuits if desired

SUPPER

As dinner or as tea
Meat extract Marmite fat free meat or chicken broth with rice o tapioca or Bournvita or Ovaltine made with skimmed milk may b taken if desired

BEDTIME

Bournvita or Ovaltine made with skimmed milk or well sweetened lemonade
Water biscuits or bread and jam

Boiled sweets may be taken after meals
Glucose may be added to drinks and stewed fruit to increase the Calorie value of the diet or when a gain in weight is advisable

Not allowed

Baked potatoes Yorkshire pudding and all foods baked in fat
Butter margarine dripping suet lard cream oil mayonnaise and all dishes containing these
Cheese
Chocolate and cocoa in all forms
Duck goose
Eggs (except egg white in the form of a meringue filled with jam)
Fat fish such as salmon herrings bloaters kippers sardines etc
Fat meat pork ham bacon sausages brawn
Fried foods of all kinds including potato chips fried onions fritters
Nuts and all sweets and biscuits containing these
Pies and pastry cakes cake mixture puddings ice cream
Shortbread petit beurre and other biscuits containing fat (Page 3°ᵤ)
Suet puddings dumplings and crust
Toffee caramels and marzipan
Whole milk fresh condensed, or sterilized

The dietetic treatment of mucous colitis is difficult The effect of a low residue diet, p 643 may be tried or that of the high residue diet used in the treatment of constipation

The Treatment of Sprue

This disease of the intestinal tract is characterized by the failure to absorb the fat of the diet although it has been properly digested The stools therefore are very bulky pale and frothy They do not appear to contain bile pigments or salts but these are actually present in normal amounts but the colour of the stool is pale because of the abundance of fat On general principles a low fat diet is indicated and the following high protein low fat diets have been arranged by N H Fairley [1]

High protein Diet 1

(Calorie value 1005)

Carbohydrate 73 grammes Protein 72 grammes Fat 45 grammes

8 a.m. Underdone beef 3 oz. juice of half an orange and glucose 2 drachms rusks ½ oz.

12 a.m. Soup 4 oz. + liver extract (equivalent to ½ lb) underdone beef 3 oz. rusks ½ oz juice of half an orange and glucose 1 drachm.

6 p.m. The same as at 12 a.m

High protein Diet 2

(Calorie value 1750)

Carbohydrate 128 5 grammes Protein 128 grammes Fat 77 grammes

8 a.m *Underdone beef 6 oz. rusks 1 oz calves foot jelly 2 oz* juice of an orange and glucose 2 drachms

12 a.m. Soup 4 oz. + liver extract (equivalent to ½ lb) underdone beef 5 oz. rusks 1 oz. juice of an orange and glucose 2 drachms

4 p.m. Tea 10 oz.; milk 2 oz.

7 p.m. The same as at 12 a.m., with calves foot jelly 2 oz

High protein Diet 3

(Calorie value 2317)

Carbohydrate 185 grammes Protein 164 5 grammes Fat 97 grammes

6 a.m Tea 10 oz milk 2 oz.

8 a.m. Underdone beef 6 oz ; rusks 1½ oz calves foot jelly 2 oz juice of an orange and glucose 2 drachms

10 a.m 1 baked apple custard 1 oz

12 a.m Soup 4 oz + liver extract (equivalent to ½ lb) underdone *beef 6 oz , calves foot jelly 2 oz rusks 1½ oz juice* of an orange and glucose 2 drachms

4 p.m. Tea 10 oz. milk, 2 oz baked apple 1 oz custard 1 oz

7 p.m The same as at 12 a.m

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[1] P Manson Bahr. (1939) *The Dysenteric Disorders* 389

High protein Diet 4

(Calorie value 2782)

Carbohydrate 223 ■ grammes Protein 179 5 grammes, Fat 116 grammes

6 a m Tea 10 oz milk 2 oz

8 a m Underdone beef 7 oz rusks $1\frac{1}{2}$ oz calves foot jelly 2 oz juice of an orange and glucose, 2 drachms

10 a m One baked apple custard 2 oz

12 noon Soup 5 oz + liver extract (equivalent to $\frac{1}{2}$ lb) underdone beef, 7 oz calves foot jelly 2 oz, rusks 3 oz juice of an orange and glucose 2 drachms

4 p m Tea 10 oz milk 2 oz 1 baked apple custard, 3 oz

7 p m The same as at 12 a m but only $1\frac{1}{2}$ oz of rusks allowed

High protein Diet 5

(Calorie value 3557)

Carbohydrate 375 grammes Protein 199 grammes Fat 123 grammes

6 a m Tea, 10 oz milk 2 oz, glucose 2 drachms rusks $1\frac{1}{2}$ oz butter 1 drachm one scraped ripe apple or one fully ripe Canary banana (yellow ends)

8 a m Underdone beef, 7 oz rusks 3 oz calves foot jelly, 2 oz juice of an orange, and glucose $\frac{1}{2}$ oz honey, 2 drachms butter 1 drachm

10 a m 1 baked apple custard 3 oz

12 a m Soup 5 oz + liver extract (equivalent to $\frac{3}{4}$ lb) underdone beef 7 oz calves foot jelly 2 oz rusks $1\frac{1}{2}$ oz juice of an orange and glucose $\frac{1}{2}$ oz

4 p m Tea 10 oz milk 2 oz, glucose 2 drachms rusks 3 oz baked apple 1 oz custard 3 oz (egg boiled or poached sometimes substituted), honey 2 drachms

7 p m The same as at 12 a m

A high protein milk is used in this diet which has the following composition SPRULAC Moisture 3 0% fat 10 6% protein 34 0% lactose 45 0% mineral matter 7 4%

LIVER SOUP —Three quarters of a pound of fresh liver is taken finely minced and immersed in a quart of water to which, when boiling a small amount of tapioca or sago and some pepper and salt should be added After simmering for two hours the fluid is strained off and allowed to cool The taste is much improved by adding stock made from beef or chicken bones

If liver ■ disliked or unobtainable full doses of liver extracts should be injected *into the muscles*

The tongue which is denuded of its papillæ and ■ very sore is best treated with riboflavine 5–10 milligrammes t d.s until the papillæ recover Nicotinamide 100–200 milligrammes t d.s should be given at the same time and ascorbic acid 100 milligrammes a day

Diets for Acute Sprue Another treatment consists in giving a diet which consists chiefly of milk, and also gives good results

DIET 1 FIRST WEEK

(Total Calorie value about 1000 Calories)

Three pints (60 oz) of cow s milk or Benger s food in 5-oz feeds at two hour intervals; toast; pulled bread Heudebert rusks or digestive biscuits with a scrape of butter

DIET 2 SECOND WEEK

(Total Calorie value about 1900 Calories)

Three pints (60 oz.) of cow s milk or Benger s food as in No 1, rusks toast sago 6 oz.; liver soup 12 oz in two feeds of 6 oz each One lightly boiled egg; weak tea or sprue tea (i e tea infused with milk) 8 oz.

DIET 3 THIRD WEEK ONWARDS

(Total Calorie value about 3900 Calories)

Breakfast	Porridge or gruel 1 egg toast and weak tea
11 a.m	10 oz. milk Sprulac or Benger s food
Lunch	Liver soup 12 oz. minced chicken 8 oz spinach (or cauliflower) 3 oz sago (or semolina) 6 oz baked apple or mashed banana 6 oz.
Tea	Toast tea madeira cake sponge cake digestive biscuits (McVitie & Price) 3 oz
Dinner	Brain or sweetbread 4 oz calves foot jelly 3 oz arrow root sago or tapioca 8 oz

Manson Bahr has found that this departure from the rigid milk dietary which was formerly advocated is of very distinct advantage to the patient, especially from the psychological point of view As a rule patients who are treated in such a liberal fashion do not manifest those signs of unreasonableness and mental irritation so typical of sprue patients whose diet was entirely restricted to milk

Diet No 1 is adjusted to a low Calorie value and while the patient is taking it, he must be kept in bed and carefully nursed Diet No 2 is of a higher Calorie value the patient may be allowed to sit up in bed and leave the room for a bath During the third and convalescent diet he may be allowed up in the afternoon

It has been the custom to augment Diet No 3 by giving raw or underdone meat up to 8 oz a day, in addition to the liver soup For this purpose the raw meat is passed through a fine mincer and spread very finely between two thin slices of bread Diet No 3 is instituted from the third week onwards and is adapted to

the special needs of each particular patient, it is usually found necessary to persist with this dietary until the stools have become normal in size and of average consistency and colour

One would have expected that the results would be better if skim milk with its low fat content were used instead of ordinary milk, as the bulk of the stools would decrease at once

It has been shown that folic acid (page 162) 10 mg twice daily by mouth will cure the macrocytic anæmia of sprue and will also cure the intestinal condition so that the stools become normal in fat content and consistency Some kinds of non tropical sprue are also cured but apparently the condition in children known as coeliac disease is not improved though the anæmia is cured [1-3]

Fresh fruit like strawberries, bael fruit and papaya had a great reputation for the treatment of sprue These like many fruits, are useful but probably owe their value to their vitamin C content and perhaps other vitamins

Constipation may be troublesome when the acute stage is over and boiled onions spinach, vegetable marrow, and especially cauli flower stalks are of great value

Diet in Constipation

Constipation [4] is usually due to one of three main causes, two of which may be helped by diet The first is ***dyschezia*** or failure of the defaecatory reflex due to careless habits, etc, in the past Diet is of little avail in this state The body must be re educated to perform the reflex

The second cause is ***spasticity of the colon,*** usually more marked in the ascending colon than the transverse or descending colon, though spasticity may extend to them as well A large

[1] Lopez Spies Toca (1946) *Journ Amer Med Assoc* 132, 906

[2] Moore Bierbaum Welch and Wright (1946) *Journ Lab & Clin Med* 30, 1056

[3] Darby-Jones and Johnson (1946) *Journ Amer Med Assoc* 130 780

[4] Readers interested in this common and much advertised complaint are advised to read Alvarez s Nervous Indigestion Barclay s The Alimentary Tract and Hurst s article in the *Encyclopædia of Medicine* III 582 From the *Lancet* 1939 I 597 we cull the following on the centenary of the publication of Sir Henry Holland s *Medical Notes and Reflections* It is certain wrote that physician to the Royal Family that the natural constitution of different persons is very various as to this point as well as the constitution of the same person at different periods of life The cases are common of individuals in perfect health who have action of the bowels only every second or third day ' Alvarez is saying the same to-day (*op cit*)

percentage of the cases of chronic constipation are due to this cause the estimates by American physicians ranging, according to Cowgill from 20 to 50 per cent Alvarez, at one time was inclined to put it still higher In this condition of the gut the circular muscles are firmly contracted and they reduce the colon to a hard rubber like tube easily felt through the abdominal wall, along which material is slow in passage

As anything *irritating to the gut in the way of coarse fibres of vegetables* bran and seeds of fruit such as tomatoes and figs increase its spasticity such foods are contraindicated and a *low-residue diet* should be given Attempts to relieve this type of constipation by recourse to the so commonly recommended roughage result in pain in the right lower quadrant of the abdomen as the consequence of distension of the cæcum and appendicitis may be suspected

The only difficulty to be met in a low residue diet is the supply of vitamin C This should be regularly given in the form of well strained orange-, lemon , grapefruit blackcurrant and rose hip juices or tomato juice The foods to avoid are brown or wholemeal bread digestive and coco nut biscuits or macaroons dried fruits wholemeal flour, fruits with edible pips and skins such as goose berries *currants figs etc green vegetables coarse root vegetables*, jams with pips and skins nuts oatmeal peas and beans shredded wheat salad vegetables The foods to take are plain biscuits white bread, butter, plain cake with no fruit cheese cream, eggs steamed white fish golden syrup or black treacle honey jelly, juices of grapefruit lemon orange, or tomato meat, milk in moderation, rusks fairy toast, or pulled bread and sugar

The third cause is ***lack of tone in the muscles*** of the large intestine, the exact opposite of the state of spasticity described above It is possible that this type of constipation is due to over activity of the sympathetic system—see the effect of cutting the sympathetic nerves to the large intestine in Hirschsprung s disease, which is an exaggerated form of atonia of the colon—and that the spastic colon is due to over activity of the parasympathetic nerves

Dietetic treatment of *atonic constipation* is along the lines of giving foods which leave a large amount of residue in the intestine

Generally speaking all foods rich in cellulose belong to this class e g oatmeal green vegetables, wholemeal bread and some fruits All of these should therefore find a place in the diet Water also acts in a large measure mechanically by increasing the fluidity of the intestinal secretion, but in part also its action may be reflex It is best given cold the first thing in the morning In districts in which the water contains much calcium a pure artificial aerated

water may be taken instead (e g Salutaris) Fats and oils, too, act as mechanical lubricants, and sufferers from constipation should partake of all of them freely, especially if the motions are small and dry Honey, treacle, and marmalade have also a slightly aperient action

It is probable, indeed, that vegetable foods owe their laxative properties in part to the fact that they are apt to undergo fermentation in the intestine, with the production of lactic and butyric acids, hydrogen, methane, carbon dioxide and hydrogen sulphide These substances chemically and mechanically stimulate the muscles of the gut to activity [1]

Beverages like beer, stout, and cider often have a laxative action, though they may cause colic in some patients Red wines are thought to be astringent, but the constipation which ensues may be due to the small amount of fluid which the wine drinker takes in the day

It was thought at one time that milk and eggs were a cause of constipation It is difficult to be certain on this point as larger amounts of these foods are usually given when the patient is strictly confined to bed, which of itself often causes constipation It is probable that some patients are affected either by milk or eggs, but the majority are unaffected Tea and coffee are said to cause constipation in some patients

The amount of fluid taken in the day should be at least 3 pints These principles are expressed in the following rules for patients

Directions for Diet in Chronic Atonic Constipation

1 The following foods should be partaken of freely
   Porridge made from medium oatmeal wholemeal bread gingerbread and ginger snaps green vegetables, *fruits (fresh or stewed—especially stewed prunes or figs* and baked apples) marmalade honey and treacle
   Fats—e g bacon fat butter salad oil
2 A glass of cold water should be taken on rising and a few French plums may be eaten before going to bed
3 A vegetable mucilage should be prescribed as it increases the bulk of the stools Agar agar is suitable and the usual dose prescribed is one teaspoonful once or twice a day Psyllium seeds are also used but they are not recommended as they may cause irritation [2]

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[1] Lawrence and McCance (1929) *Med Res Council Special Report Series* No 135

[2] Hurst (1938) *Encyclopædia of Medicine* 3, 582

Diseases of the Liver

The new hypothesis for the causation of cirrhosis of the liver has been discussed on pp 69 70 and at present holds the field The most important step in treatment is to persuade the patient to refrain from taking alcohol and this in severe cases is best done in a special home The diet should contain an adequate amount of protein 70 100 grammes a day and should contain at least 1 pint of milk—better 2 pints—a day and at least 2 oz of cheese This will ensure that plenty of methionine is absorbed and so help to reduce the fatty infiltration of the liver The fat in the diet in the form of butter and cream should be reduced to a minimum and the fat of meat and fat fish should be avoided It was customary to restrict the spices and condiments This was probably due to the occurrence of cirrhosis of the liver in India where highly spiced foods are eaten by people who do not take alcohol In the light of the new work on choline and methionine this limitation seems unnecessary Methionine may be of value in the treatment but its use has not been reported yet

At the outset the diet can be arranged as for the treatment of gastritis but eggs are best avoided because of the high cholesterol content if the patient has obstructive jaundice The amount of carbohydrate should not be too high say 250 grammes, but can be increased later on The diet should then consist of

80–100 grammes of protein	320 or	400 Calories
50– 80 grammes of fat	450 or	720
250 grammes of carbohydrate	1000	1000
	1770	2120

The protein and carbohydrate content can be increased when the appetite returns

Jaundice may be due to many causes but the general principles of diet are—so far as is known—the same The fat of the diet should be as small as possible for two reasons Firstly because if the bile is not entering the duodenum the fat will be poorly absorbed in the absence of the bile salts which lower the surface tension of the intestinal contents and so aid the fat globules to pass through the epithelium The stools are apt to be very offensive if much fat is present in the large intestine owing to bacterial decomposition Secondly it is important for the health of the liver that the fatty content should be as low as possible The type of low fat high carbohydrate high protein diet which is recommended for the treatment of cirrhosis of the liver is suitable The cholesterol

should be small in amount if the jaundice is obstructive since it is excreted in the bile In the treatment of infective hepatitis it is customary to inject in addition 6–10 units of protamine zinc insulin once a day, partly to ensure that the high carbohydrate diet does not cause any hyperglycæmia and partly to ensure that the liver contains sufficient glycogen The proteins which have a high content of methionine—milk and cheese—should be taken as well as lean meat, but eggs and fat fish should be avoided

WILSON, POLLOCK and HARRIS,[1] and HIGGINS, O BRIEN, PETERS, STEWART and WITTS[2] have tried to shorten the course of the disease—infective hepatitis—by giving methionine 5 grammes a day by mouth, but the course of the disease was quite unaffected

The 5 grammes of methionine was dissolved in a solution of 1 4 c c of concentrated hydrochloric acid and 142 c c of water An ounce of the solution containing 1 gramme was given five times a day Higgins *et al* 1945

Beattie [3] on the other hand, working with patients who had developed infective hepatitis during treatment with arsaphenamine thought that he could reduce the time the patient spent in hospital by 37 *per cent* by giving a very high protein diet—150 grammes a day He also gave methionine intravenously and obtained good results provided the total protein of the diet was high

There are but few indications to be met in the dietetic treatment of cases of ***gall-stones*** Seeing that the taking of food into the stomach stimulates the expulsion of bile, it will be well to see that the meals are rather frequent—at least five being taken in the course of the day The amount of cholesterol ingested should be reduced as much as possible by omitting eggs, brains sweetbreads liver kidneys peas, and beans since these foods contain more cholesterol than others It is believed that this procedure reduces the liability to the formation of gall stones, but of course it cannot affect stones which have already formed Most clinical observers are agreed that the drinking of large quantities of water is advisable even although there is no actual experimental evidence to show that the fluidity of the bile is increased thereby

In cases of "***biliousness***" or "***chill on the liver***"—a condition which is perhaps due to a functional disorder of the liver, the diet should be reduced to gravy soups meat extracts, dry toast, or biscuits This diet should be maintained for at least 24 hours or until the condition has improved The diet may then be increased by the addition of fruit juice or cooked fruit milk steamed fish lean meat potatoes cheese If this is well borne the diet should

[1] (1945) *Brit Med Journ* 1, 399 [2] *ibid* 1, 401

[3] BEATTIE (1943–44) *Royal College of Surgeons Scientific Report*

be increased but the fat content should be kept low and all alcohol forbidden for at least three days

4 *Disorders of the Circulation*

The stomach is only separated from the heart by the diaphragm and any distension of the stomach will tend to embarrass the heart's action If the latter is impaired it is very important to prevent the distension of the stomach with wind, and the diet which is suitable for a flatulent dyspepsia should be used (p 612)

When a severe degree of cardiac dropsy is present a dry diet is usually advised The *Karell Diet*, first introduced in 1865 consisted in its original form of 200 c c (7 oz) of skimmed milk given four times a day The amount of fluid is very small and most patients are unable to tolerate it for more than a day or two If however, the amount of fluid is increased to 1000 c c (35 oz) the treatment is believed to be of value It is better to give the drinks at more frequent intervals and six feeds of 150 c c (5 oz) should be given during the day and one during the night At least two feeds should consist of orange or lemon juice to which 15 grammes of sugar is added and the other five of milk to which 15 grammes of lactose has been added It is important to flavour the milk with coffee, cocoa Ovaltine or Benger's Food etc so as to prevent the patient tiring of the milk Such a diet would contain approximately 170 grammes carbohydrate 20 grammes protein, and 25 grammes fat calories 985 As soon as the patient is better biscuits toast cereals eggs should be added to the diet Excess of salt should be avoided but a salt-free diet should not be given

The value of ascorbic acid has been stressed by W Evans [1] He compared the action of 75 or 150 milligrammes of ascorbic acid with theobromine ammonium chloride digitalis and mersalyl on eight patients with cardiac failure associated either with normal rhythm or with auricular fibrillation The ascorbic acid increased the urinary output in every case and was sometimes more efficient and at other times less so than the other remedies Unfortunately the excretion of ascorbic acid was not estimated in these cases and it is impossible to say whether the patients were in the sub scurvy state or not The experience of one of us (G G) suggests that the ascorbic acid will only be of benefit where the previous diet has lacked vitamin C It is therefore important to make certain that a good diet has been taken and if this is not the case extra ascorbic acid should be given

[1] EVANS W (1938) *Lancet* 1, 306

A semi starvation diet has been recommended in the treatment of ***angina of effort, coronary thrombosis,*** and of ***hypertensive heart disease***[1] This treatment lowers the basal metabolic rate and so reduces the demands of the coronary circulation If the patient is overweight it is very important to make him lose weight as this by itself will reduce the work of the heart on exertion The diets suggested for weight reduction (p 603) should be used The overweight patient will not lose protein and therefore muscle in the process If the patient is already underweight it seems unwise to reduce the caloric value as the patient will probably have to use his own muscles for energy purposes and so weaken them

The dietetic treatment of ***aneurism*** must be mentioned in order to condemn it In the past reliance was placed on ***Tuffnell's treatment*** The fluid intake was reduced to 10 oz and only dry articles of food were allowed

5 *Anæmia*

In the treatment of mild chronic secondary anæmia the amount of iron in the diet should be increased Foods rich in the metal (pp 117–19) should be partaken of freely

A great advance in the treatment of pernicious anæmia has been made by the work of Minot and Murphy,[2] Castle and many others It was found that the anæmia disappeared when patients were fed on liver Half a pound was eaten each day either fried or stewed, or raw, suspended in soup and other meat extracts After the blood had become normal 5 oz was sufficient to maintain health

Most patients soon got very tired of eating this amount of liver every day and often abandoned the diet Further research has resulted in the preparation of extracts of hog's stomach and liver which can be taken by mouth These are less effective than the concentrated liver extracts which are injected intramuscularly These are now so potent that a monthly injection will maintain a normal blood picture

The rest of the diet in pernicious anæmia should consist of starchy foods with plenty of meat, vegetables and fruit Fats should be kept rather low

Folic acid It has been shown that this fraction of the B complex (page 162) when given by mouth, 10 mg twice daily, will cure the anæmia of pernicious anæmia and other hæmolytic anæmia[3]

[1] PAUL WHITE (1937) *Heart Diseases* 561 599 364 327

[2] MINOT G R and MURPHY W P (1926) *Journ Amer Med Assoc* 87, 470 CASTLE W B (1929) *Amer Journ Med Sci* 177, 748 Cit VAUGHAN J (1934) *The Anæmias* Oxford Med Press

[3] SPIES and STONE (1947) *Lancet* 1, 174

6 *Respiratory Diseases*

Pneumonia The diet in pneumonia should proceed on the same principles as in any other acute fever but as the disease is usually one of short duration and as the digestive functions are apt to be considerably impaired particular care should be taken not to overload the stomach From 2 to 3 pints of milk, plain diluted, or citrated, with half a pint of broth should be sufficient in the 24 hours Weak tea may be allowed and plenty of water or barley water The use of alcohol is unnecessary unless the patient has habitually taken a great deal and is miserable without it

Bronchitis In acute bronchitis a diet of hot slops (hot milk, broths, gruels, tea etc) is best as it tends to promote secretion from the tubes In chronic bronchitis the diet should be much on the lines of that in cases of cardiac disease (p 655), but in ill nourished patients plenty of digestible fats should be given

Pulmonary Tuberculosis The diet in this condition should follow the principles applicable in all cases of tuberculosis (p 610), but may require modification in accordance with the digestive capacity of the individual patient

Asthma In some cases the asthma attack is directly related to some article of food which the patient has eaten, e g an egg or wheat proteins Every effort should be made by careful enquiry and by the use of skin tests to discover whether this is the case If so the noxious food should either be forbidden entirely or an attempt should be made to desensitize the patient by means of subcutaneous injections of an alcoholic extract of the food

7 *Renal Diseases*

In the dietetic treatment of ***nephritis*** there are two general principles which should be observed (1) to avoid the ingestion of any article of food whose breakdown products may irritate the kidney, (2) to lighten the work of the kidney by reducing the amount of urea, uric acid creatinine, and salt which has to be excreted

Amongst the substances calculated to irritate the kidney in the process of their excretion are such articles as spices mustard pepper curry ginger radishes and perhaps asparagus Alcohol especially in concentrated forms is also strongly contra indicated as some of it is always excreted in the urine, and of non alcoholic beverages ginger ale should be avoided owing to the fact that it contains either ginger or capsicum or both

The various types of nephritis demand very different dietetic treatment

(*a*) *Acute diffus nephritis associated with hæmaturia little or no œdema, but with retention of urea in the blood* Formerly this type of disease was treated with milk and some physicians gave their patients 3 pints of milk in the day for long periods This diet contains C 80 P 60 F 60 Cals 1156, sodium chloride 0 72 grammes (11 1 grains) The amount of nitrogen which has to be excreted in the urine on this diet is 8 4 grammes (allowing 1 gramme for excretion in the stools), provided that the patient is in nitrogenous equilibrium But as the total Caloric value of the diet is only 1156 (or about 844 less than the 2000 Calories which are assumed to be necessary for a patient lying in bed) the patients will not be in nitrogenous equilibrium Such a patient will use up body proteins and will excrete more than 8 4 grammes of nitrogen a day These considerations show that a diet of milk by itself is not a satisfactory one

Recently the use of orange and lemon juice with the addition of sugar has been recommended as putting the least possible strain on the kidney

This diet is very palatable when patients are unwell and is of especial value if they suffer from nausea or vomiting Under these conditions 2 to 3 oz should be given every hour The Caloric value of this diet if 250 grammes of glucose are given, is only 1000 and as the diet does not contain any protein the patient will not be in nitrogenous equilibrium, and will have to break up valuable body proteins A boy of 12 with acute nephritis whose blood urea was within normal limits, lost 66 6 grammes of nitrogen in the urine in the course of 12 days daily (an excretion of 5 5 grammes of nitrogen or 11 8 grammes of urea (Fig 28) If the 1 gramme which was possibly lost in the stools each day is neglected the total loss of protein in the 12 days was 346 8 grammes, and the total loss of flesh (66 6 grammes nitrogen × 30) 1998 grammes or nearly 4 lb In the next 7 days he was given 36 grammes of protein and 200 grammes of sugar and 50 grammes of fat total Calories 1486 He excreted slightly more nitrogen in the urine [illegible] 81 instead of 5 51 grammes and the average daily loss of nitrogen was 0 41 grammes (neglecting the possible loss of 1 gramme of nitrogen in the stools the total nitrogen lost in 12 days was 4 92 grammes When an additional 100 grammes of carbohydrate, Calories 1696 was given the average daily excretion of nitrogen in the urine was [illegible] 67 grammes and a positive balance of 0 63 gramme was attained (neglecting the possible loss of 1 gramme of nitrogen in the stools)[1] This experiment showed that a diet consisting of orange juice and

[1] Figures of a case of acute nephritis treated by one of us (G G) unpublished

sugar caused a loss of valuable protein while a diet containing 30 grammes of protein with adequate amounts of fat and carbohydrates preserved the body protein and increased the secretion of nitrogen by the kidney from 5 5 to 5 67 grammes only a negligible amount which could certainly have been prevented by giving another 25 grammes of glucose or 100 Calories. If the kidneys are incapable of doing their work, as shown by an increase in the blood urea, it is clearly of importance to keep the protein of the diet as small as possible Chittenden[1] enjoyed excellent health and was kept in nitrogenous equilibrium for nine months on 36 6–40 grammes of protein *This diet necessitated the excretion of from 1 80 to 5 4* grammes allowing for the daily excretion of 1 gramme of nitrogen in the stools

These considerations show that it is desirable in cases of acute nephritis in which retention of urea occurs to reduce the protein to 30–40 grammes When the blood urea is very high the total protein of the diet may be reduced to 25 or 30 grammes for a short while When such a small amount of protein is being eaten nearly all of it should consist of first class proteins and the caloric value of the diet must be higher than the 2000 Calories which is suitable for a patient lying in bed say 2500–3000 If the caloric value is not adequate the patients will not be in nitrogenous equilibrium and will have to break up their body proteins If this occurs the general nutrition of the body will suffer and the kidney condition will deteriorate When a very low protein diet is given it is essential to estimate the total amount of nitrogen excreted in the urine in the 24 hours for two to three days to make certain that the caloric value of the diet is adequate to spare the body proteins Alving[2] believes that patients do better with a higher protein intake, although the blood urea is too high He thought this was caused by an improvement in the general nutrition of the patient It may be due to the fact that it is much easier to keep a patient in nitrogenous equilibrium with a protein intake of 50 60 grammes than with only 30 grammes since the caloric intake need not be so high

The kind of protein which should be given has been much disputed The milk proteins were regarded as of especial value and no other kind of protein was allowed Later it was realized that egg albumin was as free from objection as milk and later still also that fish proteins were not injurious and comparatively recently that meat proteins could be given without causing any harm to

[1] Cit GRAHAM LUSK (1919) *Science of Nutrition* 337
[2] ALVING A. S (1934) *Medical Clinics of N America* 17 1195

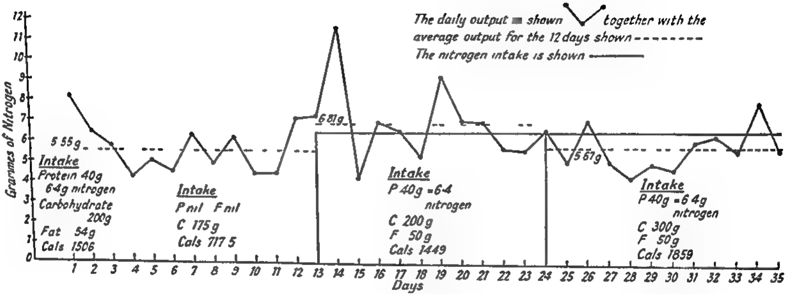

FIG [illegible] SHOWS THE OUTPUT OF TOTAL NITROGEN DURING THREE 12 DAY PERIODS BY A BOY AGED 13½ WITH ACUTE NEPHRITIS

The blood urea was within normal limits throughout the period. The urine contained blood and albumin. The nitrogen in the fæces was not estimated

the patient All the four kinds of proteins mentioned are digested in the same way (see p 241) and are broken down by the pepsin and trypsin to the stage of polypeptides and then absorbed into the bloodstream in the form of amino acids They are then either (1) deaminized and the nitrogen is converted into urea in the liver or into ammonia by the kidney and so excreted into the urine while the carbohydrate moiety is utilized for energy purposes or (2) used for building up or repair of the body proteins such as the albumin, globulin and fibrinogen of the blood But fish besides proteins also contains purine bodies and meat contains the extractives creatinine and creatin as well as the purines Thus the eating of fish and meat increases the intake and therefore the output by the kidney of uric acid and creatinine They should therefore be avoided when the blood urea is raised above the normal 40 milligrammes per 100 c c , but if it is normal fish and meat proteins are not contra indicated

These considerations suggest that the diet should be arranged as follows

(1) At the onset of the disease and especially if the patient is very ill with nausea and vomiting the diet should consist of orange-juice and water and at least 250 grammes of glucose Some loss of valuable muscle protein is inevitable at this stage

(2) As soon as the patient has lost the nausea a low protein diet containing 30–40 grammes should be given together with a high carbohydrate diet sufficient to prevent the breakdown of body proteins The protein should be in the form of milk eggs bread rice etc The fat should be 50 grammes or less

(3) If and when the blood urea is normal the total protein of the diet may be increased to 50–60 grammes (an excretion in the urine of 8–9 5 grammes nitrogen) and fish and meat may be added to the diet if the patient desires them and the carbohydrate and fat increased so as to keep the patient in nitrogenous equilibrium

(b) The treatment of *chronic diffuse nephritis which is associated with much œdema and little or no hæmaturia*

In this condition the blood urea is usually normal but large amounts of protein 10–15–30 grammes may be lost each day the total blood proteins are reduced from 7 to 4 5 grammes or less owing to the loss of albumin and to a lesser extent of globulin The osmotic pressure of the albumin is high and when the amount of albumin is less than 2 grammes œdema appears A cardinal point of treatment is therefore the raising of the amount of albumin in the blood above the critical level The best way of doing this would be to stop the loss of albumin by the kidneys but apart

from keeping the patient warm in bed and protected from chill no remedies are available Since the albumin of the blood must be built up from the amino acids derived from the foods the amount of protein in the diet is important The amount lost each day may be as high as 15–30 grammes and if the intake were only 30 grammes the destruction of the body proteins would be considerable It is essential to increase the protein intake but it is difficult to say how much should be given

Epstein[1] recommended that a high protein diet should be given, of the following composition—protein 120–140 grammes, carbohydrate 150–300 grammes fat 20–40 grammes, Caloric value 1293–2176 Alving[2] thought that patients did better with a diet consisting of 90–125 grammes of protein, and a Caloric value of at least 2500 The physiological evidence suggests that the body must be in nitrogenous equilibrium if new albumin is to be made If this is the case the large amount of amino-acids circulating in the blood should aid in the formation of new albumin If the concentration of the albumin increases in the blood it will drain fluid from the tissues into the blood and so disperse the œdema A high protein diet also aids in the excretion of water since urea is a good diuretic, and the additional urea derived from the protein, is of value in this respect McLean recommended that 30 grammes of urea should be given by mouth for this purpose It seems a pity not to give the extra protein which will supply the urea for diuretic purposes and at the same time provide the amino acids which may be used for the formation of albumin

It must be remembered that a high protein diet should never be given if the blood urea is over 40 milligrammes per 100 c c and that it should be estimated at weekly intervals whenever such a diet is given A kidney which is capable of excreting 8 grammes of nitrogen a day may fail badly if it is required to excrete 16 to 20 grammes If the blood urea begins to rise the protein intake should be reduced at once and the blood urea estimated more frequently

A salt poor diet is often of value when œdema is present, for the salt may be retained and with it an isotonic equivalent of water, which will increase the œdema[3] When this diet (details on pp 676–8) is given the plasma chlorides should be estimated at intervals and if the figure falls below 370 milligrammes per 100 c c, the intake of sodium chloride should be increased It is unnecessary

[1] EPSTEIN (1917) *Amer Journ Med Sci* *Journ Amer Med Assoc* 1917

[2] ALVING A S (1934) *Medical Clinics of N America* 17, 1195

[3] ALVING A S *ibid*

to restrict the intake of water provided a salt poor diet is prescribed for water by itself is readily excreted An intake of at least 2000 c c (3 pints 8 oz) should be allowed as an intake of 1000 c c (1 pint 9 oz) makes life unpleasant for the patient

Chronic Renal Disease (Chronic Interstitial Nephritis) This condition is often associated with (1) a raised blood pressure and (2) a raised blood urea It is doubtful whether the height of the blood pressure can be influenced by any article of food The custom of spending one day each week in bed and abstaining from meat or soup on that day probably owes its beneficial effects to the rest and not to the avoidance of meat and its extractives Alcohol should be forbidden when the blood pressure is high If the patient is overweight he should submit to the dietetic regime suitable for obese patients (p 603) If the blood urea is raised a low protein diet of high calorie value should be given sufficient to keep the body in nitrogenous equilibrium

The condition is usually associated with an acidæmia and the alkali reserve may be considerably less than the normal values of 55 to 70 volumes (25–35 milli-equivalents) of carbon dioxide for 100 c c blood It may be associated with an alkalæmia if much vomiting has occurred with the result that the alkali reserve may be 80–90 vols (36–40 milli-equivalents) per 100 c c blood If the alkali reserve is only slightly lowered say to 50 vols it may be raised to within normal limits by avoiding the acid forming foods like meat and eating those forming alkalies like vegetables (p 129) If this is unsuccessful and if the alkali reserve is less than 50 volumes of carbon dioxide per 100 c c blood (25 milli-equivalents) a definite dose of alkali say 2–6 grammes (30–90 grs) of sodium bicarbonate must be taken two or three times a day the alkali reserve must be estimated at intervals to make certain that the correct dose of alkali is given If the alkali reserve is slightly too high say 75 vols (33 7 milli equivalents) per 100 c c more acid and less alkali forming foods should be eaten If this fails or if the alkali reserve is over 75 vols (33 7 milli-equivalents) per 100 c c acid sodium phosphate 1–3 grammes (15–45 grains) should be given by mouth

The plasma chloride varies between the normal limits of 580–620 milligrammes (96–106 milli equivalents) per 100 c c and in cases of renal failure it often varies inversely with the alkali reserve When the latter is high the plasma chloride is low and cannot be raised by increasing the salt intake of the diet This is the experience of one of us (G G) An intravenous injection of 1000–2000 c c of normal physiological saline or Ringer's solution containing 9–18 grammes of sodium chloride will raise the plasma chlorides and depress the alkali reserve temporarily further treatment must

DIET FOR ACUTE NEPHRITIS

	Carbo hydrate	Protein	Fat	Calories
1st Feed				
4 oz Milk	5 0	3 6	4 4	76
1 oz Bread (Butter from ration)	15 0	2 4	0 3	70
2nd Feed				
4 oz Orange juice	10 0	—	—	41
1 oz Sugar	28 4	—	—	116
3rd Feed				
4 oz Milk	5 0	3 6	4 4	76
1 oz Bread (Butter from ration)	15 0	2 4	0 3	70
½ oz Jam	10 0	—	—	41
4th Feed				
4 oz Orange juice	10 0	—	—	41
1 oz Sugar	28 4	—	—	116
5th Feed				
4 oz Milk	5 0	3 6	4 4	76
1 Egg	—	6 8	7 0	92
1 oz Bread (Butter from ration)	15 0	2 4	0 3	70
6th Feed				
4 oz Orange juice	10 0	—	—	41
1 oz Sugar	28 4	—	—	116
7th Feed				
4 oz Milk	5 0	3 6	4 4	76
1 oz Bread (Butter from ration)	15 0	2 4	0 3	70
¾ oz Jam	15 0	—	—	61
8th Feed				
4 oz Orange juice	10 0	—	—	41
1 oz Sugar	28 4	—	—	116
DURING THE NIGHT				
1st Feed				
4 oz Milk	5 0	3 6	4 4	76
1 oz Bread (Butter from ration)	15 0	2 4	0 3	70
2nd Feed				
4 oz Orange juice	10 0	—	—	41
½ oz Sugar	14 2	—	—	58
Butter ration for the day = 1 oz	—	—	24 0	220
	292 8	36 8	54 5	1871

This diet contains approximately sixty 5-gramme carbohydrate portions and five 7 gramme protein—5 gramme fat portions with the addition of 1 oz of butter (See 'Food Tables' pp 593–5)

Diet for Chronic Nephritis with a Raised Blood Urea

	Carbo hydrate	Protein	Fat	Calories
Breakfast				
½ oz. Dry Oatmeal as porridge	10 3	1 9	1 1	60
4 oz. Milk for tea and porridge	5 0	3 6	4 4	76
2 oz. Bread	30 0	4 8	0 6	140
1 oz. Jam or Marmalade	20 0	—	—	82
Two 5 gramme portions of Fruit say 4 oz Apple	10 0	—	—	41
Midday Meal				
2 oz. Chicken	—	9	2 2	[illegible]
4 oz. Potatoes	20 0	—	—	[illegible]
Green Vegetables		Negligible		
Two 5 gramme portions of Fruit say 4 oz. Orange	10 0	—	—	41
2 oz. Bread	30 0	4 8	0 6	140
Tea				
2 oz. Bread	30 0	4 8	0 6	140
1 oz. Jam	20 0	—	—	82
1 oz. Plain Cake	15 0	1 8	6 8	130
2 oz. Milk	2 5	1 8	2 2	38
Evening Meal				
1 oz. White Fish	—	5 22	—	[illegible]
4 oz Potatoes	20 0	—	—	82
2 oz Bread	30 0	4 8	0 6	140
2 oz. Milk	2 5	1 8	2 2	[illegible]
Two 5 gramme portions of Fruit say 2 oz. Banana	10 0	—	—	41
2¼ oz Butter in the day	—	—	[illegible]	495
1½ oz Sugar in the day	42 6	—	—	174
	307 9	43 1	75 3	2070

This diet contains approximately sixty two 5 gramme carbohydrate portions and seven 7 gramme protein—5-gramme fat portions with the equivalent of 2¼ oz of butter The diet contains little first-class protein but it can be increased without adding to the total protein if the chicken or fish is increased and potatoes and fruit substituted for some of the bread which contains a good deal of vegetable protein Thus if the amount of bread in the above diet is reduced from 8 oz to 4 oz the protein is reduced from 19 2 to 9 6 grammes which would allow another 2 oz of chicken The reduction in the carbohydrate intake of 60 grammes is made up by giving another 6 oz of potatoes or 2 oz dry rice as a pudding and six 5 gramme portions of fruit say the juice of 3 oranges (See pp 593–5)

be guided by the results of blood analysis The amount of fluid given to these patients should be considerably increased above the usual amount of two pints a day A careful watch must be kept for œdema of the back and legs The kidney is often only able to secrete a urine of low specific gravity and the more fluid it has to secrete the greater the chance that it will be able to excrete the urea and other substances which tend to be retained The daily intake should be increased to three or four pints in the day This extra fluid will not be retained in the circulating blood but will be rapidly excreted in the urine so long as the myocardium is healthy [1] If the latter begins to fail as shown by the appearance of œdema of the legs the cardiac condition should be treated with the appropriate measures and the fluid intake should not be reduced except as a last resort, as it is very important to maintain the action of the kidneys

The use of alcohol is contra indicated in all types of nephritis

If a high protein diet is required for the treatment of *nephrosis* the protein ration should be increased to 85 or 110 grammes and the fat to 94 or 114 grammes (twelve or sixteen protein fat portions) (see Food Tables pp 593–5) and the carbohydrate should be increased by 50 grammes (ten 5 gramme portions) so as to maintain the patient in nitrogenous equilibrium

8 *Diseases of the Nervous System*

Dietetic means are of comparatively little value in the treatment of nervous diseases In most cases the food must be adapted to the condition of the patient s other organs

Epilepsy This condition has in the past been treated with various dietetic restrictions such as abstinence from meat, purines, and alcohol the substitution of sodium bromide for sodium chloride was also advocated Experience has shown that none of these régimes has any real effect but that a ketogenic diet in which the carbohydrate ration is very small in amount and the fat ration very large is of more value [2] The exact mode of action of the diet in producing this result is obscure, some writers attribute the benefit to an anæsthetic action of the ketone bodies others to an effect of the diet in diminishing fluid retention in the tissues [3] McQuarrie [4] found that the patients with no definite lesions and

[1] PRIESTLEY J G (1931) *Journ Physiol* 55 305

[2] PETERMAN (1924) *Amer Journ Dis Children* 27, 28 (1927) *Journ Amer Med Assoc* 88, 1868

[3] MORIARTY (1927) *Amer Journ Dis Children* 33, 218

[4] MCQUARRIE I (1933) *ibid* 29, 208

KETOGENIC DIET

Child aged 2[1]	Child aged 5[2]	Child aged 8-12[3]	Adult[4]
BREAKFAST			
Egg	1 egg	1 egg	2 oz Tomato
½ oz Butter	2 oz Bacon	2 oz Bacon	½ oz Bacon
	½ oz Butter	1 oz Butter	½ oz Butter
			1 oz Devonshire Cream
			Coffee

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Note Bran biscuits or food valueless biscuits obtainable from Callard & Co may be taken as desired

[1, 2, 3] GARROD BATTEN and THURSFIELD (1934) *Diseases of Children* Third edition 1582

[4] ABRAHAM and WIDDOWSON (1937) *Modern Dietary Treatment* 225

those treated before the onset of severe attacks did the best Thus out of 160 cases treated for several years 36 per cent were apparently cured 20 per cent improved and 43 per cent not benefited

The patient is kept in bed for a week and given only water, gravy soup, bran biscuits, and a little orange juice The fast is broken with a diet which is calculated in the following way The caloric requirements of a child at rest should be worked out with the use of the nomograph (p 48) or from Holt's table (p 50) The carbohydrate should not be more than 10–13 grammes The protein is arbitrarily fixed at 1 gramme per kilogramme as the diet will not be of long duration and the remainder of the calories are made up with fat The diets on p 667 are suitable

The diet is given until the fits cease in favourable cases, it is important to continue the diet for another three months when all being well the amount of carbohydrate can be cautiously increased and the fat gradually decreased

When the diet is used in the treatment of urinary *infections* it should be calculated in the same way For the treatment of an adult a diet containing 10–13 grammes of carbohydrate, 50–60 grammes of protein and 250 grammes of fat should be arranged The active principle in this case is the excretion of β oxybutyric acid (Fuller)[1] This kills the bacteria more effectively when the pH of the urine is 5 2 or more It is usually necessary to give ammonium chloride 1 gramme (gr 15) in a cachet three or four times a day in order to make the urine sufficiently acid The treatment is often successful but may fail because the amount of β oxybutyric acid formed is insufficient This is often due to the patient breaking the diet and eating carbohydrate

The diet is nowadays little used as it has been replaced by the administration of (1) mandelic acid which Rosenheim[2] showed killed the bacteria as well or better than β oxybutyric acid when the pH of the urine was 5 2 and (2) by the sulphonamide group of drugs, which have the additional advantage that they work best in alkaline urine

Certain neurological conditions which may either be a severe neuritis or a sub acute combined degeneration of the cord may occur when the patient has a pernicious anæmia or a hæmolytic anæmia though it may occur in patients who are not *anæmic* The condition is greatly improved by intramuscular injections of a potent liver extract Folic acid one of the fractions of the vitamin B complex (page 162) which cures the anæmia, has no

[1] FULLER A T and COLEBROOK I (1933) *Lancet* 2, 735

[2] ROSENHEIM, M L. (1935) *ibid*, 1, 1032

effect on the neurological conditions which may develop while the folic acid is being given [1]

Chorea is a complication of Rheumatic Fever which usually occurs in children Special care must be taken in feeding children when the movements are very violent A fluid diet of this type used for the treatment of an acute fever should be given though the calorie value need not be so high since the temperature is usually normal

In the treatment of *headaches*—especially of the periodic migrainous or bilious variety—diet is sometimes of great help During the attack the patients usually eat and drink very little and should be allowed to have anything they may fancy The evidence that migraine is caused by certain foods is not convincing, as the offending food is very difficult to determine either by the history or skin tests If any food is known to be followed by headache it should not be eaten

Various types of diet are sometimes useful a strict purine free diet (p 614) with the avoidance of the methyl purines in tea coffee a considerable reduction in the amount of meat eaten a strict vegetarian diet the avoidance of all fancy diets A full calorie diet should be given between the attacks so as to ensure good health

9 *Diseases of the Skin*

There are four ways in which diet may conceivably influence the skin [2] (1) By affecting general nutrition (2) reflexly from the alimentary canal, (3) by giving rise to the absorption into the blood of irritating or decomposition products or by producing allergy (4) by the elimination through the skin of certain constituents of the food

It must be admitted however that when we come to use dietetic methods in the actual treatment of cutaneous disorders we find our selves greatly hampered both by our ignorance of the precise part played by diet in any given case and by the always unknown factor of personal idiosyncrasy So much is this the case that it may be said without fear of contradiction that there are but few diseases of the skin in which treatment by diet is of much value and that the potentialities of this line of attack are much less promising than patients generally believe

In the great majority of cases of skin disease therefore either no special rules of diet are required, or they must be drawn up with reference to the patient s general condition without regard to

[1] SPIES and STONE (1947) *Lancet* 1 174

[2] WALTER SMITH (1898) *Brit Journ of Dermat* 7 328

the state of the skin There are a few cutaneous diseases, however, in which diet may be of some direct help and these may be briefly considered

Urticaria This is the clearest instance of a skin disease being affected by diet *The urticarial wheal develops some hours after eating either a common article of food like shellfish, fish eggs* pork or bacon milk, cheese, pickles strawberries and other fruits, or to some uncommon food to which the patient is sensitive Sometimes it only develops when the food is not quite fresh The treatment consists in avoiding the special article of food This is easy if the food is an uncommon one, but difficult to achieve in the *case of a common article like an egg In the latter case an attempt* should be made to desensitize the patient by subcutaneous injections of an alcoholic precipitate of the offending substance

Eczema Some cases are caused, or made worse, by some articles of food like rhubarb, tomatoes sour fruits, pungent articles like ginger over ripe cheese, and high game Children may be sensitive to milk or eggs Alcohol usually aggravates the con*dition either because of the impurities which give the flavour to* the wine or spirit, or by dilating the skin capillaries In some cases a strict milk diet may be helpful if it is known that the patient is not sensitive to it The diet should always be plain and simple so that any injurious article of food can be easily detected *A low-salt diet does not appear to be of any value If a patient is* fond of rich food and is inclined to be stout, a general reduction of food and drink is often beneficial

Acne Vulgaris and Seborrhœa These conditions are apparently made worse by excess of carbohydrate food and especially of chocolates It has been found that the constituent in chocolate which aggravates the acne is cocoa butter

Lupus vulgaris This condition has been treated with Finsen light for many years and it has long been thought that the improvement which *occurs is due to* the calciferol which is formed by the ultra violet rays in skin Treatment with big doses, 150 000 I U of calciferol by mouth, will often cure the condition

In ***psoriasis*** various ' systems ' of diet occasionally meet with success Bulkley [1] recommends absolute vegetarianism, forbidding *even milk and eggs, and says he has seen the worst eruptions disappear* under such a plan, whilst *per contra* the quite opposite regimen of meat and hot water only,[2] or an exclusively milk diet, has proved

[1] *Journ Amer Med Assoc* (1908) Feb 22

[2] PARKES (1874) *Lancet* 1, 722 and MALCOLM MORRIS (1906) *Practitioner* 76, 575

successful in the hands of others In the majority of cases diet has probably little or no influence

In *rosacea* the diet should be arranged to meet any form of dyspepsia which may be present (pp 623 *et seq*) but alcohol tea coffee spices and anything which causes flushing of the face must be rigidly excluded

In *pruritus* especially of the anus or vulva all highly seasoned salted, or preserved foods should be avoided besides alcohol and coffee Should diabetes be present the dietetic indications are, of course the same as for that disease (pp 583 *et seq*)

In concluding this section one cannot do better than quote the wise words of an eminent dermatologist [1] After all, it is in comparatively few cases of skin disease that the diet is really of any particular importance Put not your faith in printed dietaries or indeed in any general formularies Above all remember that the patient has larger and better opportunities of observation than the doctor, and, if he is a person of ordinary intelligence and self-control, he should be trusted The doctor who attempts to dictate as an oracle in the matter of diet is like Lord Foppington s bootmaker who insisted that he knew better than his client whether or not the shoe pinched

[1] Malcolm Morris *op cit* 76 681

CHAPTER XXIII

SOME DIETETIC "CURES" AND "SYSTEMS

In the earlier part of this book reference has been made t so called milk, whey koumiss, grape and orange ' cures " I present chapter we propose to deal briefly with some of the elaborate ' systems ' of diet which are sometimes useful in treatment of disease That such systems are occasionally of therapeutic value no one can deny, but they must be used creetly, bearing in mind the dangers and fallacies inherent attempts to treat disease on a "system' regardless of the pecu ities of the individual case, and remembering that no such sy can ever be a panacea, but is at best of restricted, and often of temporary value The reckless and uncritical advocacy of faddist can only serve to bring such systems into disrepute

Vegetarian and Lacto vegetarian Diet

In a previous chapter (pp 447–50) the question of vegetariar was discussed in detail and the conclusion arrived at that it is *a form of diet which is to be unreservedly commended for heal* persons None the less, as a mode of treatment in certain of disease, such a regimen is deserving of the careful consideratio the medical profession, and all the more that hitherto it has b mainly exploited by the large body of "amateur' practition

There are certain well recognized peculiarities and properties a non flesh diet which justify the expectation that it will prove use in some morbid states In the first place, such a diet is compa tively free from the purine bodies, the share of which in the prod tion of gout has already been discussed (pp 612–13), besides co taining almost always less total protein than a mixed diet In t second place, a diet from which flesh is excluded and which conta a large proportion of milk, tends greatly to restrain the process putrefaction in the intestine Now there is some reason to belie that certain obscure conditions of general ill health may be produc and maintained by the absorption of such putrefactive produc In the third place, such a diet is peculiarly rich in inorganic mater if milk, eggs, and cheese are included and although the part play

by these in metabolism is at present but ill understood, there is yet reason to believe that by altering the "balance" of the salts in the body, nutrition may sometimes be influenced for good It also reduces the intake of acid forming substances and tends to raise the alkali reserve In the last place, a diet which is of mainly vegetable composition leaves a large residue in the bowel and may counteract a tendency to constipation of the atonic type with all its attendant evils moreover it increases the intake of vitamin C

Much careful observation and clinical experiment will certainly be required before we are able clearly to discern exactly in what cases a diet of this sort is likely to be of benefit, but meantime the following list of diseases in which there is at least presumptive evidence that a vegetarian or lacto vegetarian regimen exercises a beneficial influence may be tentatively put forward [1]

(1) Corpulence complicated by atonic constipation in middle life

(2) Certain cases of alcoholism

(3) Some forms of functional dyspepsia and intestinal affections of nervous origin

(4) Idiopathic neuralgias and those having a gouty basis

(5) Headaches and other disorders dependent on atonic constipation in neurasthenic, hysterical and epileptic patients

(6) Many cases of nervous insomnia

It is almost always wise to make the change from an ordinary diet gradually and in many cases it is inadvisable to continue the vegetarian plan for longer than six weeks at a time unless the patient has been greatly benefited

Fruit and Raw Vegetable Cures

We have referred elsewhere (p 438) to the so-called 'Grape Cure,' but from time to time diets have been introduced into which raw fruit and vegetables enter largely if not exclusively Lahmann advocated such a diet many years ago and it has been re introduced in Germany [2] Its chief feature is the large use of fresh fruit and raw vegetables with little meat and no common salt the place of which is taken by a vegetable salt Fresh milk, eggs and whole

[1] See L Kuttner (1902) *Berliner Klinik* Jan Albu (1902) *Die Vegetarische Diat* (Leipzig Georg Thieme) 130

[2] E Müller (1930) *Med Klinik* No [illegible] See also Von Noorden (1928) Über Obstkuren und über Rohkost *Therap d Gegenw* 69 289 It is sometimes called the Sauerbruch Hermannsdorfer Gerson Diet after its chief advocates at present (see Chalmers Watson (1930) *The Med Press* September 10 207)

meal bread are allowed in moderation Lahmann also advised the use of vegetable fats in cooking

Such a diet is of course, of low protein and caloric value and from the character of its mineral constituents is "alkalizing" It is to a large extent also 'salt free' (see p 675), and has a laxative tendency

These diets may be expected to be of use in obesity and atonic constipation and to have some diuretic action and may be advised *in the same diseases and disorders as a vegetarian or lacto vegetarian* regimen

A diet consisting *of the juice of eight to twelve oranges is some* times recommended This contains 40–60 grammes of sugar and an excess of vitamin C, but no protein

The Hay Diet

In this system it is recommended that protein and carbohydrate should not be eaten at the same meal It is claimed that an almost unbelievable gain in health results from this procedure The diet has also been used as a cure for obesity It has already been pointed out (p 95) that when protein is eaten without any carbohydrate, the amino acids are broken down immediately so that the carbo hydrate fraction of the amino acid can be used for energy purposes The NH_2 group is converted into urea and excreted in the urine Thus *none of the amino acids are available for conversion into* protein for use in the body The same observation has now been made with the intravenous injections of protein digests for patients who cannot take any food by mouth (p 688) It was found neces sary to give glucose at the same time in order to prevent the excretion of the whole of the nitrogen into the urine within a short time In the light of this experimental evidence the principle of eating *all* the *animal* protein *at one meal without any carbohydrate foods* would mean that all the amino acids derived from the first class protein would be lost and that the amino acids derived from the *second class proteins* present in wheat etc, would have to be used for building up into the body proteins Thus the experimenters would be much worse off than the vegetarians who do at least use the first class protein present in milk, cheese and eggs For these reasons we do not propose to give any *details of the diets* used as we unhesitatingly consider that they are dangerous

Exclusive Protein Diet

That man *can live on* a predominatingly protein diet is un doubtedly true The Eskimos have used this diet for ages and

Stefansson[1] in his Arctic expeditions showed that it was possible to live on animal and fish foods alone He felt well and was able to undergo great hardships The amount of fat eaten with the protein is considerable

He and Anderson lived on this diet for a year in the United States and under close supervision in the Bellevue Hospital for three months and were passed fit in every respect

Such a diet was practised years ago under the name of the *Salisbury cure* and great claims were made for it e g that it cured or alleviated chronic articular gout some skin diseases such as psoriasis and certain intractable forms of dyspepsia especially when associated with atonic dilatation of the stomach The system has fallen into desuetude and is omitted in this book The details of the treatment will be found in earlier editions

Zomotherapy

By the term ' zomotherapy (*Zωμo* meat juice) is meant treatment by raw meat or raw meat juice This was used in the treatment of patients with anæmia neurasthenia debility convalescence and latent incipient or active tuberculosis There is no evidence that raw meat juice aids these conditions and its use is fraught with some risk since the eggs of parasites may be ingested Details of the diet will be found in the 7th edition

Low-Salt Diet

The average amount of common salt in an ordinary diet is about 10 grammes per day and although it is impossible even were it desirable to construct a genuinely salt free diet yet by a judicious selection of foods it is easy to reduce the daily intake to about 2 grammes Such a limitation of salt is of use in the treatment of dropsy particularly the dropsy of chronic parenchymatous nephritis It was shown by Widal—to whom much of the credit of introducing the salt-free diet is due—that a chronically inflamed kidney is incapable of excreting common salt freely It is now known that the sodium is excreted with difficulty while the chlorine ion is readily excreted with potassium (Blum) The salt is therefore retained in the body and in order that the normal composition of the body fluids may be maintained water is kept back also with the result that dropsy sets in When the amount of salt in the food is reduced the percentage of it in the blood gradually falls the salt which has been stored up in the dropsical effusion is drawn upon to

[1] STEFANSSON V (1936) *Adventures in Diet*

meal bread are allowed in moderation Lahmann also advised the use of vegetable fats in cooking

Such a diet is, of course, of low protein and caloric value and from the character of its mineral constituents is ' alkalizing ' It is to a large extent also salt free ' (see p 675) and has a laxative tendency

These diets may be expected to be of use in obesity and atonic constipation and to have some diuretic action, and may be advised in the same diseases and disorders as a vegetarian or lacto vegetarian regimen

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Exclusive Protein Diet

That man can live on a predominatingly protein diet is undoubtedly true The Eskimos have used this diet for ages and

Diet II

(*Less strict, containing about 0 5 gramme sodium chloride*)

Breakfast

Grapefruit with sugar
Low salt bread
Low salt butter
Boiled egg
Jam or marmalade
Tea or coffee with cow s milk and sugar as desired

Lunch

Beef stewed without salt Curry powder may be added if desired
Potatoes and boiled rice
Vegetables boiled without added salt or soda
Baked apple
Cream if desired

Tea

Low salt bread
Low salt butter
Jam marmalade honey, tomato or mustard and cress
Shortbread
Tea with cow s milk and sugar as desired

Dinner

Cold boiled chicken or steamed fish
Green salad or celery, radishes or tomato with pepper
Low salt bread
Low salt butter
Tea coffee or cocoa with cow s milk and sugar as desired

The salt contents of some common articles of food are—

	mg per oz		mg per oz
Ham	595	Lentils	10
Bacon	314	Flour	8
Cheese	260	Nuts	1–8
Bread (baker s)	146	Greens	2
Fresh butter	63	Rice	[illegible]
Sea fish	34–54	Potatoes	1
Egg	47	Fruit	1
Meat	20	Freshwater fish	Low
Milk	12	Peas	Trace
Oatmeal	10		

The Potassium poor Diet

The preparation of a potent extract from the cortex of the adrenal gland which is now used in the treatment of patients with Addison s disease has greatly increased our knowledge of this disease It is now known that the adrenal cortex controls the sodium of the body

and that in Addison's disease the blood sodium is lower than the normal of 325 to 350 milligrammes per 100 c c while the potassium in the blood is increased above the normal of 18 milligrammes per 100 c c because the blood volume is concentrated [1] Further work has shown that there is a direct antagonism between the potassium and sodium of the blood [2] Thus in a case of Addison's disease an increase in the potassium intake from 1 to 4 grammes lowered the blood sodium from 325 to 310 milligrammes per 100 c c in five days and increased the output of sodium in the urine from 220 milligrammes to 440 milligrammes a day

These observations suggested that a diet containing little potassium might be of value in the treatment of Addison's disease It has been found that with this diet the expensive cortical extract necessary for health can be either greatly reduced in amount or given up altogether Unfortunately the diet is apt to be unattractive and lacking in variety The tables prepared by Miss M. Abrahams late Dietitian at St Bartholomew's Hospital and her colleagues are very useful in arranging a diet and should enable patients to get the variety which they need In a recent case (under the care of G G) the blood potassium decreased from 24 to 18 milligrammes when 10 grammes of sodium chloride was given, kept at 18 milligrammes with the use of salt and 10 c c of cortical extract and decreased from 18 milligrammes to 13 5 milligrammes when a diet containing 1 5 grammes only of potassium was given although no cortical extract was given

The potassium poor high sodium diets must be used with caution when desoxycorticosterone one of the active principles extracted from the adrenal cortex is used either by injection or by implantation of a pellet The general condition usually improves greatly the blood chemistry becomes normal but some œdema of the legs may develop and the blood pressure may rise In some of these cases death may occur very suddenly at the very moment that the prognosis seems especially good It is believed that the low potassium in the blood plays some part and it seems wiser not to prescribe a low potassium diet when desoxycorticosterone is being given but to restrict its use to the mild cases which do not need any injections of cortical extracts [3, 4]

[1] LOEB R F (1932) *Science* 76 420

[2] WILDER R M SNELL, A M KEHLER E J RYNEARSON E H ADAMS M and KENDALL E C (1936) *Proc Mayo Clinic* 11 273

[3] KUHLMAN D RAGAN C FERREBEE J W ATCHLEY D W and LOEB R F (1939) *Science* 90 496

[4] TOOKE T B POWER M H and KEPLER E J (1940) *Proc Mayo Clinic* 365

THE POTASSIUM POOR DIET CONTAINING 1 50 GRAMMES OF POTASSIUM

	Potassium (grammes)
BREAKFAST	
2 oz white bread	0 10
1 egg	0 07
1¾ oz raw apple or other fruit amount in list (or containing 0 05 gramme K)	0 05
2 oz milk in tea or coffee	0 10
DINNER	
3 oz roast beef mutton pork steamed or fried cod or steamed plaice or six times any other meat or fish in the list	0 30
2 oz carrots or marrow or other vegetables amount in list (or containing 0 05 gramme K)	0 05
2½ oz potatoes cut very small and cooked in eight times their volume of water	0 10
5 oz stewed apples or 5 oz stewed pears or other fruit, twice amount in list (or containing 0 10 gramme K)	0 10
¾ oz cheddar cheese and ⅝ oz sweet or water biscuit *or* ¾ oz cereal and 1 oz cream as pudding (cereal cooked in water with sugar *and cream added before serving)*	*0 05*
TEA	
2 oz white bread	0 10
1½ oz jam or 1 oz lettuce or ½ oz tomatoes	0 05
2 oz milk in tea	0 10
SUPPER	
1½ oz white bread or ⅞ oz biscuits not digestive	0 07
1½ oz salmon or haddock or chicken or 3 oz stewed beef or boiled mutton or three times meat or fish in list	0 15
2 oz orange or other fruit twice amount in list (or containing 0 10 gramme K)	0 10
2½ oz butter all day	0 01
	1 50

Sugar or glucose butter suet and salt may be taken as desired
Ordinary gravy and the water from cooked fruit or vegetables must not be used
Special gravy may be made with cornflour and water, coloured with browning and salted

PORTIONS OF CARBOHYDRATE FOODS CONTAINING 50 MILLIGRAMMES OF POTASSIUM

(A) Vegetables Cooked in the usual way

	oz.		oz.
Asparagus boiled	2	Brussels sprouts	¾
Broad beans boiled	¾	Cabbage boiled	1¾
Beans French or runner	1¾	Carrots boiled	2
Beetroot boiled	¾	Cauliflower boiled	1

(A) Vegetables Cooked in the usual way—continued

	oz		oz
Celery boiled	1¼	Peas dried boiled	¾
Celery raw	¾	Potatoes old boiled	½
Cucumber raw	1¾	Potatoes new boiled	½
Leeks boiled	¾	Radishes	¾
Lentils raw weight	¾	Spinach cooked without water	½
Lettuce	¾	Spring greens boiled	1¾
Marrow	2	Swedes boiled	1¾
Onions boiled	2¼	Tomatoes	½
Onions spring raw	¾	Turnips	1
Parsnips boiled	¾	Watercress raw	½
Peas fresh boiled	1		

Vegetables Cut very finely and cooked in eight times their volume of water

	oz		oz
Asparagus	2½	Parsnips	1½
Cabbage	1½	Peas fresh or tinned	1½
Carrots	2½	Potatoes	1½
Cauliflower	1½	String beans	1½
Onions	2½	Turnips	2½

(B) Fruits

	oz		oz
Apricots dried stewed	½	Lemon juice	1½
Apricots raw fresh	¾	Melon cantaloupe or yellow	¾
Apples raw eating	1¾	Orange or orange juice	1
Bananas	½	Peach fresh raw	¾
Blackberries stewed	1½	Peach dried stewed	½
Blackcurrants stewed	¾	Pears raw eating	1¾
Cherries raw	¾	Pears stewed	2½
Cherries stewed	1½	Pineapple raw	¾
Currants dried	½	Plums raw dessert or stewed	1
Damsons raw	¾	Prunes	½
Damsons stewed	1	Raisins dried	½
Green figs	¾	Raspberries raw	½
Gooseberries ripe raw	1	Raspberries stewed	1½
Gooseberries unripe stewed	1½	Red currants raw or stewed	½
Grapes	¾	Rhubarb stewed	½
Grapefruit	¾	Strawberries raw	1
Greengages raw	½	Sultanas dried	½
Greengages stewed	1	Tomatoes raw	½

(C) Nuts

	oz		oz
Almonds	¼	Cobnuts	½
Barcelonas	¼	Desiccated coco-nut	¼
Brazils	¼	Peanuts	¼
Chestnuts	¼	Walnuts	¼

The above fruits are weighed with their stones if they are usually served with them

THE POTASSIUM POOR DIET CONTAINING 1 50 GRAMMES OF POTASSIUM

	Potassium (grammes)
BREAKFAST	
2 oz white bread	0 10
1 egg	0 07
1¾ oz raw apple or other fruit amount in list (or containing 0 05 gramme K)	0 05
2 oz milk in tea or coffee	0 10
DINNER	
3 oz roast beef mutton, pork steamed or fried cod or steamed plaice or six times any other meat or fish in the list	0 30
2 oz carrots or marrow or other vegetables *amount in list (or* containing 0 05 gramme K)	0 05
2½ oz potatoes cut very small and cooked in eight times their volume of water	0 10
6 oz stewed apples or 5 oz stewed pears or other fruit twice amount in list (or containing 0 10 gramme K)	0 10
¾ oz cheddar cheese and ⅛ oz sweet or water biscuit *or* ¾ oz *cereal and 1 oz cream as pudding (cereal cooked in water with* sugar and cream added before serving)	0 05
TEA	
2 oz white bread	0 10
1½ oz jam or 1 oz lettuce or ½ oz tomatoes	0 05
2 oz milk in tea	0 10
SUPPER	
1½ oz white bread or ⅞ oz biscuits not digestive	0 07
1½ oz salmon or haddock or chicken or 3 oz stewed beef or boiled mutton or three times meat or fish in list	0 15
2 oz orange or other fruit twice amount in list (or containing 0 10 gramme K)	0 10
2½ oz butter all day	0 01
	1 50

Sugar or glucose butter suet and salt may be taken as desired
Ordinary gravy and the water from cooked fruit or vegetables must not be used
Special gravy may be made with cornflour and water, coloured with *browning and salted*

PORTIONS OF CARBOHYDRATE FOODS CONTAINING 50 MILLIGRAMMES OF POTASSIUM

(A) Vegetables Cooked in the usual way

	oz.		oz
Asparagus boiled	2	Brussels sprouts	¾
Broad beans *boiled*	¾	Cabbage boiled	1½
Beans French or runner	1¾	Carrots boiled	2
Beetroot boiled	½	Cauliflower boiled	1

(A) Vegetables Cooked in the usual way—continued

	oz		oz
Celery, boiled	1½	Peas dried boiled	¾
Celery raw	½	Potatoes old boiled	½
Cucumber, raw	1½	Potatoes new, boiled	½
Leeks boiled	½	Radishes	¾
Lentils raw weight	¾	Spinach cooked without water	½
Lettuce	¾	Spring greens boiled	1½
Marrow	2	Swedes boiled	1½
Onions boiled	2½	Tomatoes	½
Onions spring raw	¾	Turnips	1
Parsnips boiled	¾	Watercress raw	½
Peas fresh boiled	1		

Vegetables Cut very finely and cooked in eight times their volume of water

	oz.		oz.
Asparagus	2½	Parsnips	1½
Cabbage	1½	Peas fresh or tinned	1½
Carrots	2½	Potatoes	1½
Cauliflower	1½	String beans	1½
Onions	2½	Turnips	2½

(B) Fruits

	oz		oz
Apricots dried stewed	½	Lemon juice	1½
Apricots raw fresh	¾	Melon cantaloupe or yellow	¾
Apples raw eating	1¾	Orange or orange juice	1
Bananas	½	Peach fresh raw	¾
Blackberries stewed	1½	Peach dried stewed	½
Blackcurrants stewed	¾	Pears raw eating	1¾
Cherries raw	¾	Pears stewed	2½
Cherries stewed	1½	Pineapple raw	¾
Currants dried	¼	Plums raw dessert or stewed	1
Damsons raw	¾	Prunes	¼
Damsons stewed	1	Raisins dried	¼
Green figs	¾	Raspberries raw	¾
Gooseberries ripe raw	1	Raspberries stewed	1½
Gooseberries unripe stewed	1½	Red currants raw or stewed	¾
Grapes	½	Rhubarb stewed	½
Grapefruit	¾	Strawberries raw	1
Greengages raw	½	Sultanas dried	¼
Greengages stewed	1	Tomatoes raw	½

(C) Nuts

	oz		oz
Almonds	¼	Cobnuts	¼
Barcelonas	¼	Desiccated coco-nut	¼
Brazils	¼	Peanuts	¼
Chestnuts	¼	Walnuts	¼

The above fruits are weighed with their stones if they are usually served with them

(D) Starchy Foods

	oz		oz
Biscuits sweet or water	1¼	Flour	1¼
Biscuits digestive	½	Oatmeal or *Quaker Oats* raw weight	½
Biscuits cream crackers	1¼	Rice raw weight	1⅓
Bread brown	½	Rusks	¾
Bread white	1	Tapioca	10
Cornflour	2¾		

(E) Sugar Rich Foods

	oz		oz
Chocolate, plain or milk	⅛	Honey	3½
Cocoa	¼	Jam	1¼
Golden Syrup	¾	Marmalade	4

PORTIONS OF PROTEIN AND FAT CONTAINING 50 MILLIGRAMMES OF POTASSIUM

	oz		oz
Bacon raw weight	¾	Lobster boiled	¾
Beef corned	1½	Milk fresh whole	1
Beef roast or salt boiled	¼	Milk evaporated sweetened or unsweetened	¾
Beef, stewed	1	Milk skimmed sweetened condensed	⅓
Butter	12	Mutton boiled	¾
Cheese cream	4	Mutton roast	½
Cheese cheddar	1½	Mutton neck stewed	1
Cheese soft	2	Plaice steamed	¾
Chicken boiled or roast	½	Pork roast or salt boiled	½
Cod steamed or fried	½	Rabbit	¾
Crab boiled	¾	Salmon fresh steamed or tinned	⅛
Cream 50 per cent	1¾	Sardines tinned	¼
Egg (one contains about 70 milligrammes of Potassium)		Sole steamed	¾
Haddock fresh or dried steamed	½	Sweetbreads	¾
Hake	¼	Tripe stewed	16
Ham lean boiled	1½	Veal roast	½
Kidney stewed ox	1		

FOODS CONTAINING NEGLIGIBLE AMOUNTS OF OR NO POTASSIUM

Sugar glucose lactose
Butter suet
Tapioca
Tripe

SOUR MILK TREATMENT

Curdled milk has long entered into the diet of many countries in the Near East (e g Roumania Bulgaria, the Caucasus) and owing to the vivacious advocacy of Metchnikoff it had an enormous

vogue in this country in the early years of this century Soured milk therapy is still practised and has some advantages in treatment of dyspepsia

The theory of its use is that the milk souring bacilli antagonize the growth of the putrefactive bacilli and so, if established in the large intestine prevent the production of histamine tyramine, indol, and phenol in that part of the body Metchnikoff assumed without sufficient evidence that the products of putrefaction shortened life [1]

The ' fermentation of milks [2] in their country of origin is used to preserve the milk, and to make a pleasant and ' stimulating ' comestible Yeasts and lactic acid bacilli are used for this purpose Of the bacilli the strains utilized are the *Bacillus bulgaricus* (Metchnikoff) which occurs naturally in the cow, the *Bacillus acidophilus* found in man and the *Bacillus bifidus* found in the alimentary tract of the infant The differences are very slight but the *Bacillus bulgaricus* is more resistant and more active Cultures of lactic-acid producing microbes (usually cocci) are utilized in the souring of milk for the production of margarine

The intention of the use of soured milk in medicine is (1) to change the flora of the large intestine and (2) to produce an easily digested milk Of the two reasons the latter is the more important for the curds are smaller and softer than those normally produced in digestion of whole milk It is not possible to change the flora of the intestine merely by feeding cultures by the mouth but excess of lactose in the diet will encourage the growth of lactic acid producing microbes in the large intestine even in the absence of soured milk or artificial cultures taken via the mouth

Commercial preparations of the lactic acid bacilli are put up in the form of tablets and ampoules Both contain negligible quantities of living bacilli if taken by the mouth but can be used as starters in building up a culture

The Preparation of Acidophilus Milk (1) *From whole milk* Boil the milk and cool it to about 42° C Inoculate the milk with 1 tablet of a good commercial culture and keep it either in a thermostat at 42° C or in a thermos flask at this temperature for about 24 hours Subculture it daily by adding two to three tablespoonfuls to freshly boiled milk when its temperature has fallen to about 24° C It takes about a week before a sufficiently good culture is obtained and the milk curdles in about 12 hours The curdled milk can either be eaten at once or placed in a refrigerator until it is wanted

[1] Metchnikoff (1907) *The Prolongation of Life* 16

[2] For the account of these products the authors are indebted to Dr Cuthbert Dukes

(ii) *From unsweetened condensed milk.* Pour the milk into a scalded pan. Wash out the tin with an equal quantity of boiling water and add it to the condensed milk. Allow it to cool as above and add the commercial culture.

Commercial Preparations of Soured Milk. *Kéfir.* An effervescent soured milk prepared in its country of origin from cow's, goat's or sheep's milk. Kéfir "grains" are used. These are masses of yeasts, moulds, and lactic acid producing bacilli. These are inoculated into the milk, which is kept in large leather bottles which are kept warm and shaken periodically. This soured milk contains 1 per cent. lactic acid and 2 per cent. alcohol.

It is prepared in this country by adding Kéfir grains (obtainable from the Lister Institute) and commercial strains of lactic acid organisms to pasteurized milk kept at room temperature for 12 hours. The resulting fluid is strained and fermented for 24 hours at 12–16° C. The higher the temperature the more alcohol and the lower the more lactic acid is formed.

Koumiss is fermented mare's milk.

Yoghourt. The countries of origin are the Balkan States. It is made from cow's or sheep's milk, boiled to half its volume, cooled and inoculated with some of the previous preparation as a starter. It consists of a semi-solid creamy substance containing 2–3 per cent. lactic acid and bacilli of the *Bulgaricus strain plus strepto cocci.* There is no alcohol in this preparation.

Sundry dairy firms will carry out the production of Kéfir and Yoghourt in this country.

The value of soured milk as a therapeutic agent is somewhat doubtful, but it has been recommended in cases of chronic ill health without obvious cause, in neurasthenia and intestinal affections—e.g. colitis, fermentative diarrhœa, constipation—besides gout, arterio sclerosis and some skin diseases. As regards many of these affections it may be pointed out that there is little or no proof that they are really the result of intestinal putrefaction, and any improvement which soured milk may produce in them is probably to be ascribed to the fact that it provides an easily digested form of food and so improves the patient's nutrition. In cases of hyper chlorhydria and chronic gastritis soured milk is contra indicated.

CHAPTER XXIV

ARTIFICIAL FEEDING AND ARTIFICIAL AND PREDIGESTED FOODS

In this chapter we shall consider the methods of administering food otherwise than by the mouth and describe some patent and artificial foods not yet dealt with

Artificial Feeding

Rectal Feeding and Nutrient Enemata

Rectal feeding has constituted a therapeutic resource ever since medical science existed [1] but it is only within recent times that the value of this method of administering nourishment has been subjected to careful scientific scrutiny

Water is readily absorbed in the form of tap water It is best given by a continuous rectal drip at the rate of 125 c c per hour and 3000 c c can be given in the 24 hours if nothing is taken by mouth Normal physiological saline or Ringer s solution are not well tolerated as the salt irritates the mucous membrane so that they soon cease to be absorbed In any case if 3000 c c were given in the day it would entail the giving of 27 grammes of sodium chloride which would be too much for the kidney to excrete If one fifth normal physiological solutions are used they are much better retained and the total salt administered in 3000 c c is 5 4 grammes which the kidney should be able to excrete easily One third normal physiological solutions are also used and 3000 c c would mean the excretion of 9 grammes of sodium chloride

Carbohydrates Glucose is the only sugar which can be absorbed from the large intestine If used in a high concentration it irritates the mucous membrane and is rejected after a while Mutch and Ryffel [2] found that a 6 per cent solution was well tolerated and

[1] For a sketch of the history of the subject see the valuable monograph by A P Gros *Traitement de certaines Maladies de l Estomac par la Cure de Repos absolu* etc Paris 1898

[2] Mutch N and Ryffel J H (1913) *Brit Med Journ* 1, 111

this can be given either in tap water or one-fifth normal physiological saline as a rectal drip at the maximum rate of 125 c c per hour, or 3000 c c per 24 hours if nothing else is taken by mouth or intra venously In this way 180 grammes of glucose can be administered and supply 738 Calories

While the evidence is in favour of the absorption of glucose alone of the sugars from the solutions given per rectum (Tallerman)[1] it is not clear whether the sugar is absorbed from the large intestine or whether it must pass into the small intestine before absorption can take place Davidson and Garry[2] have shown that prac tically no absorption of glucose or of any mono saccharide takes place from the large intestine and cæcum of the rat When, how ever sugar was injected into the small intestine of the rat under the same conditions of anæsthesia, etc, a large proportion of the sugar was absorbed

Proteins The absorptive power of the large intestine for proteins has been investigated many times and it was thought by earlier workers that substances like peptone, eggs with salt, raw beef juice were well absorbed, but later observations tend to throw much doubt upon the trustworthiness of the earlier experiments upon the absorption of proteins from nutrient enemata Rendle Short and Bywaters for instance, who reinvestigated the whole subject, came to these conclusions

1 The older observations on the absorption of foodstuffs from rectal enemata, based on the analysis of rectal "wash outs" are unreliable

2 The daily output of nitrogen in the urine of patients given nutrient enemata of milk or eggs peptonized for twenty or thirty minutes demonstrates that almost no nitrogenous matter is absorbed

3 Modern physiological opinion holds that proteins are absorbed principally as amino acids The failure of the rectum to absorb ordinary nutrient enemata is largely due to the fact that peptones are given instead of amino acids

4 Chemically prepared amino-acids, or milk pancreatized for 24 hours so that amino acids are separated, allows of a much better absorption of nitrogenous foodstuffs from the rectum as demon strated in five cases by the high nitrogen output in the urine

5 The low output of ammonia nitrogen shows that this high output was not due to the absorption of putrefactive bodies The rectal washings were not offensive

[1] TALLERMAN (1920) *Quart Journ Med* 13, 356

[2] DAVIDSON J N and GARRY, R C (1939) *Journ Physiol*, 96, 172

A practical disadvantage of the old nutrient enemata was the *amount of putrefaction which occurred in the bowel and the most* offensive smell which was noticed when the bowels were opened These observations which have been fully confirmed are so striking that nutrient enemata containing protein which has not been well digested with pancreatic juice in order to liberate the amino acids should not be used and all details of such nutrient enemata are omitted in this section

PEPTONIZED MILK ENEMA

Boil 1½ pints of milk in flask cool to 37° C
Add ½ oz of an active pancreatic preparation
1½ oz of glucose
Keep at 37 C for 24 hours
Give 6–7 oz every four hours
A daily rectal washout should be given

The value of this nutrient enema is very doubtful and other methods of feeding are much better

Fats These have been given as a suspension but there is little evidence that they are absorbed and they should not be given

Nutrient suppositories cannot be recommended They usually contain peptone but at most not more than 8 grammes in each which means even assuming complete absorption an energy value of less than 35 Calories The value of such suppositories is negligible

INTRAVENOUS FEEDING

Water Sugar and Salt These are best administered by the intravenous route if a patient cannot take anything by mouth For a short infusion the vein may be pierced by a fine needle but for a long infusion one to three days it is better to cut down on a small vein and tie in a canula The antecubital veins should not be used except in emergency as it is very uncomfortable for the patient to keep his arm quite still A cannula should never be tied into this vein as this will destroy it completely

If after an abdominal operation a patient can take nothing by mouth he should be given a five per cent glucose solution either in normal physiological saline or Ringer s solution followed by 2000 c c of one fifth normal physiological saline or Ringer s solution con taining five per cent of glucose If nothing is given by mouth this amount of fluid is well tolerated and will contain 150 grammes of *glucose supplying 615 Calories and 12 6 grammes of sodium chloride*

This procedure can be continued for one to two weeks and the patients can be kept quite comfortable as they do not suffer from

lack of fluid or sodium chloride The caloric value is low, 615 Calories, and the patients will lose about 5 to 7 grammes of nitrogen a day which must come from the breakdown of muscle protein, and will also lose a good deal of fat (see p 605)

If it is given for more than two days at least 25 milligrammes of ascorbic acid should be added to the perfusion fluid If the patient had not been saturated with ascorbic acid before the operation, at least 1000 milligrammes a day should be given for three days in order to ensure the healing of the wounds

On physiological grounds it would seem preferable to use Ringer s solution in order to supply calcium and potassium in addition, which are essential for life This is a little more complicated to prepare than normal saline If however, the sodium bicarbonate is omitted it is just as easy to sterilize as normal saline It is, how ever, little if at all used by the medical profession This may be due to three causes

(1) The initial difficulty of preparing a stable solution, which prevented its use originally

(2) It is not as a rule provided

(3) The innate conservatism of the surgeons who chiefly use these solutions

Amino acids Protein hydrolysates in intravenous alimenta tion

Various attempts have been made to give patients sufficient food to maintain life at a high level by intravenous methods These have been successful in the hands of research workers and may soon be available for ordinary use and a short account of the work is given here The proteins have been digested either by hydrolysa tion with acids alkalis, or with enzymes The disadvantage of the acid hydrolysation of casein is that tryptophane is destroyed in the preparation and it together with methionine and cystine must be added The alkaline hydrolysate preserves the tryptophane but destroys the methionine and cystine and a mixture of acid and alkaline hydrolysates has been advocated but its trial has not yet been reported Digestion with enzymes like trypsin or papain or with a mixture (Beattie) has been used These have the advantage that the amino acids are not destroyed but the digestion takes several days instead of a few hours and sterility of the mixture is difficult to maintain

Technique A solution of protein hydrolysate plus 10 per cent glucose is made up in cold freshly distilled water and passed through a Berkefield filter autoclaved for 30 minutes at 5 lb pressure (Elman 1940) This is injected into a vein at a rate 300–500 c c an hour

As much as 3000 c c in the 24 hours containing 75 grammes of protein hydrolysate and 300 grammes of glucose (Calories 1537) have been given and this has been maintained for 23 days by Elman [1] It is possible in this way to maintain the body in nitrogen equilibrium and in weight Taylor [2] (1943) gave much larger doses—200 grammes of the protein hydrolysate together with 300 grammes of protein by mouth to a patient who was very ill with extensive burns The treatment was continued for over 40 days and the patient, who at the outset seemed likely to die recovered

The injections have been responsible for reactions like flushing and burning of the skin, headache backache rigors, abdominal pain nausea vomiting phlebitis and thrombosis These are probably due to some impurities and may cease as the method of preparation improves

Examination of patients who have died during the course of treatment showed that the hydrolysate was not responsible for any of the deaths

The protein hydrolysates have been used for patients with malignant disease of the œsophagus stomach and ulcerative colitis and it was usually possible to maintain nitrogen equilibrium If however the output of nitrogen was very large as occurs after operations it was not possible to attain nitrogen equilibrium (Elman 1939 1940)

Good results have been obtained in patients with severe burns [2] The results with dysentery and severe ulcerative colitis are good but those with liver diseases are conflicting Alstruter *et al* [3] 1942 thought they were contra indicated but Landesman and Weinstein [4] Stewart and Rourke [5] found that the patients used the digests and often with benefit They are also of value in promoting the regeneration of plasma proteins after hæmorrhage and it was found that cystine was of greater value than methionine which is not present in horse serum albumen [6]

The possibilities opened up by this method of intravenous feeding are very great It is to be hoped that the preparation will soon be readily available as this may well turn the scale with many very ill patients who at present receive intravenous therapy with sugar salt and water only

They should be useful in the treatment of patients with mal

[1] Elman and Lischer (1943) *Ann Surgery* **118** 225
[2] Taylor *et al* (1943) *Ann Surgery* **118**, 215
[3] Altstruter and Taylor (1943) *Arch Inst Med* **70** 749
[4] Landesman and Weinstein (1942) *Surg Gyn Obst* **75**, 300
[5] Stewart and Rourke (1942) *Proc Soc Exp Biol Med* **51** 369
[6] Brand and Kassell (1941) *J Bio Chem* **141** 999

nutrition but the evidence at present suggests that plasma given intravenously to begin with is more useful for the very ill patients

Subcutaneous Feeding

The injection of nutritive substances under the skin was first introduced by Menzel and Perco in the year 1869 [1] and is now very little used as this has been replaced by the intravenous route Sugar and salt may be given subcutaneously in the same quantities as for intravenous infusions if these cannot be performed and the patient cannot take anything by mouth or by the rectum

Artificial Foods

The objects of artificial foods may be said to be either (1) to present a maximum of nourishment in a minimum of bulk, or (2) to enable one easily to enrich the diet in respect of certain of its chemical constituents

In regard to the former of these objects it is well to realize at the outset what degree of concentration of food is chemically possible Let us take first the case of the proteins Lean meat may be regarded as the type of a natural protein food It contains about one fifth of its weight of that constituent, the rest being chiefly made up of water If all the water is driven off from 5 oz of meat there will be left behind about an ounce of what is practically pure protein Now this may be regarded as the maximum degree of concentration of which protein food is capable In other words, an ounce of any artificial protein food can never represent more than 5 oz of lean meat A more concentrated protein food than that is a chemical impossibility We can realize from this the absurdity of such preparations as beef lozenges Even if these did consist of pure protein (which they never do) it would require 1 oz of them at least to be equal in food value to 5 oz of fresh meat, so that the amount of nutriment contained in one lozenge must be very small indeed

Or take, again, the case of the carbohydrates There is no form of carbohydrate food more concentrated than sugar Any fluid or semi fluid carbohydrate preparation must inevitably be of lower nutritive value than sugar, for it contains some water, the food value of which is nil Such preparations as malt extracts therefore can never add to the diet as much carbohydrate as an equal weight of ordinary sugar

[1] For the history of subcutaneous feeding see BAUER The Dietary of the Sick' (Von Ziemssen's *Handbook of General Therapeutics*, 1, 271) and LEUBE in LEYDEN s *Handbuch der Ernahrungstherapie* 1, 513

The same is true of *fats* No artificial preparation can have a higher food value than pure olive oil, which contains no water or dripping from which all the water has been driven off by heat Ordinary butter contains four fifths of its weight of pure fat

There are then distinct limits beyond which the concentration of foods cannot be carried and the idea that food tabloids' might be prepared one or two of which would be the equivalent of an ordinary meal is seen to be an impossible dream At the most all that the maker of concentrated artificial foods can hope to do is to drive off from the natural food the excess of water which it contains and even then most if not all of the original water must be returned to the food before it can be eaten

It may be questioned too *whether the use of highly concentrated foods is physiologically defensible* The digestive organs are not constructed for the disposal of foods in an extremely compact form Such forms of nutriment make large demands upon the secretory powers of the stomach and are apt to be irritating to the digestive organs in addition to which the total absence in them of ballast renders them unable to supply an adequate stimulus to the peristaltic movements of the intestines As exclusive foods therefore such preparations are eminently unsuitable

The second object of these substances that of enabling us to *enrich the diet in certain ingredients* is more legitimate Here the artificial food is used simply as an accessory to supplement the lack of protein carbohydrate or fat in other articles of diet Their small bulk is here a decided advantage for it enables them to be added to fluid foods without appreciably increasing the total amount of material to be swallowed and in many cases of illness this is a desirable thing to do

We may conclude then that concentrated foods are only to be used as accessories and that they have no legitimate place in the dietary of health

In cases of illness however they have a definite but limited sphere of action In these circumstances when appetite is in abeyance it is often a question not so much of getting the patient to take much nourishment as of persuading him to eat at all It is then that the artificial foods serve a useful purpose for they can be varied to suit the caprices of the patient and though the amount of actual nourishment which they yield may be small they may yet kindle a desire for ordinary foods The value of any artificial preparation in such a case is not to be estimated by the amount of energy it yields so much as by its æsthetic qualities and the degree to which it pleases the patient Suggestion, in fact plays a large

part in bringing about whatever good results artificial foods are capable of producing

Artificial Protein Foods

1 **Undigested—*(a) Of Animal Origin*** Probably the best of the undigested protein foods are now derived from casein, the chief protein of milk In a previous chapter most of these, e g Plasmon and Casumen, have been described They have the advantage of being colourless tasteless and readily soluble, so that they can easily be added to other foods, besides which they are digested without difficulty and are very completely absorbed

Of the artificial protein foods derived from meat, most belong to the predigested class to be considered immediately The "dehydrated" meats or fish are usually soaked in water before serving and so regain all the water which was removed in its preparation Although very palatable and making excellent mince or ketcheree they can hardly be described as concentrated foods

Dried milk is a concentrated food and can be added to any drink to thicken it Dry skim milk can be added to milk

(b) Of Vegetable Origin The chief vegetable protein foods are ***Aleuronat, Legumin, and Glidine***[1] The first is a special preparation of gluten containing 81 6 per cent of protein It is a yellowish brown powder, almost insoluble in water, and can be conveniently used as an addition to semi solid foods

Legumin (vegetable casein) is the chief protein of pulses and is a valuable and highly nutritive substance apt, however, to have a rather bitter taste

Glidine is prepared from wheat protein and contains [illegible] per cent protein It is easily soluble and can be added to any foods

2 **Digested Protein Foods or Peptone Preparations** These had at one time a considerable vogue in dietetics The proteins are partially broken down in the normal stomach to peptones and albumoses (p 238) If these products are given to a healthy person they are further broken down in the course of digestion to polypeptides and amino acids in the same way as the original proteins and are therefore capable of replacing them Their use should relieve the stomach of some of the preliminary work of digestion In practice this is of little value as the stomach and intestines are rarely so damaged that they are unable to digest the protein of eggs and milk Further, these products are liable to cause diarrhœa for some unknown reason if given in large amounts, but are well tolerated in small quantities

[1] Many of the preparations are at present unobtainable

The following tables contain analyses of some of the semi solid and liquid peptone preparations

Most of these contain so much water that their nutritive value is comparatively small, while those in which alcohol is present are open to the same objections as dietetic or medicinal wines (see p 517)

COMPOSITION OF PEPTONE PREPARATIONS

	Water	Insoluble Proteins	Soluble Proteins chiefly Albumoses	Extractives	Carbohydrate	Fat	Inorganic Constituents	Alcohol
Peptonized Milk	87·5	—	1·76	—	10%	3·3	?	—
Fairchild's Panopepton	[illegible]	—	6·5	?	16·5 %	—	1·0	18 [illegible]%
Benger's Peptonized Meat Jelly	89·69	—	7·16	2·27	—	—	0·89	—
Somatose	59	—	17	4	—	—	4	—
Peptalac (Cow and Gate)	87·9	—	4·2	—	6·2%	0·9	0·8	—
Carnrick's Peptonoids	—	—	35·8	—	48%	—	8%	—

Home made peptonized foods can easily be prepared with such agents as liquor pancreaticus or zymine (see p 687) Milk which has been peptonized in this way is still used though many doubt its value

Gruels of various sorts can be prepared in a similar way, peptonized milk gruel being one of the best Such home made preparations are mostly to be preferred to commercial articles and have also the advantage of being very much cheaper

ARTIFICIAL CARBOHYDRATE FOODS

Many patent foods which might justly be included in this section have been already dealt with under the cereals pulses etc or in the section on Infant Foods The only group which remains to be considered is that of the *malt-extracts* These are prepared by evaporating down an infusion of malted barley at low temperatures or *in vacuo* The object of evaporating them in that way is to preserve in an active form the diastatic ferment present in the malt and the special apparatus required for this purpose is one cause of the expense of such preparations

The following table contains the results of the analyses of some standard malt-extracts

COMPOSITION OF MALT EXTRACTS

	Total Solids	Reducing Sugars as Maltose	Protein	Dextrin	Ash	Alcohol	Diastatic Power Lintner Units
Kepler Extract of Malt	78 5	65 5	5 5	6 2	1 3	—	900–1000
D C L Malt Extract	81 1	?	[illegible] 82	?	1 11	—	60
Cream of Malt	79 4	62 6	6 5	8 2	1 4	—	40
Standard Malt Extract	79 4	60 3	6 5	10 5	1 4	—	30–40
Standard Liquid Malt Extract	53 [illegible]	40 4	4 35	6 8	0 9	9 0	10–20
Extract of Malt	80	50 5	5 2	—	1 2	—	—
Bynin	63 4	59 6	3 2	—	0 9	8 3	—
Maltine	78	61 9	6 0	5 0	1 2		1000

The average value of these foods is 57 grammes of sugar 5 8 grammes of protein 6 3 grammes of dextrin, and the caloric value is 283 per 100 grammes 1 oz yields about 80 Calories or a little more than one egg The diastatic value is low except in the Kepler Extract of Malt

In the above analyses the whole of the nitrogenous matter has been counted as protein, but it is very doubtful if that is quite accurate Some of the nitrogen is almost certainly present in other forms

Malt extracts may be prescribed with one of two objects (1) To enrich the supply of carbohydrates in the diet (2) to aid the digestion of starchy foods by means of the diastase which the extract contains The advantages possessed by malt extracts for accomplishing the former of these objects are not quite apparent *Treacle and golden syrup* both contain a considerably higher percentage of sugar and are vastly cheaper It is true that malt sugar is less apt to irritate the stomach than the cane sugar which treacle and syrup contain and although not capable of direct absorption as such maltose may yet be regarded as a partially digested form of carbohydrate But in both these respects we have in ordinary honey a superior food

Honey has the following composition

Water	[illegible] to 13 per cent
Invert sugar	71 4
Cane sugar	2 69
Protein	0 4
Ash	0 12

That is to say that it is actually richer in sugar than malt-extract, but has less protein and no dextrin the caloric value of 1 oz is 104 Furthermore, the sugar of honey is really in a predigested form, and ready for immediate assimilation As a source of carbohydrate, therefore, honey is in every way preferable to malt extracts, besides being a good deal cheaper and it may be used with great advantage in every case in which one wishes to supplement the supply of carbohydrates in the diet

The second property of malt extracts—that of acting upon starch by means of the diastase which they contain—is but rarely present in the mind of the prescriber The cases in which such an action is desired are not, indeed at all numerous and are practically confined to the group of so called amylaceous dyspepsias Even in such a case malt-extract is not the best preparation to employ No matter how carefully the extract may be prepared, it always seems to lose something of its diastatic power in the process and it is far more certain, as well as cheaper and one may add pleasanter to make an infusion of malt at home and either use it as a beverage at meals, or preferably, stir it into starchy foods such as puddings or gruel, before they are eaten

The value of *milk sugar* as a means of supplementing the carbohydrates of the diet must not be forgotten Its comparative freedom from sweetness makes it specially suitable for such a purpose If ½ oz of it is dissolved in 5 or 6 oz of milk, the nutritive value of the latter is increased by nearly 60 Calories This may often be taken advantage of in feeding patients with acute fevers As explained above it can be used to depress the activity of putrefactive organisms in the large intestine

The number of preparations used in medicine which contain the various vitamins either alone or in combinations is getting very large and it is important that their content should be known

By the courtesy of the Editor of *The Pharmaceutical Journal* a list of commercial preparations containing vitamins appeared in the 1940 edition of this book This was compiled from information supplied or published by the manufacturers and was intended to serve as a guide to the nature potency and source of the preparations listed The particulars concerning the potencies of the preparations are the claims made by the manufacturers No attempt was made by the *Pharmaceutical Journal* to verify them by actual tests on the products themselves

The list is now brought up to date by the *Pharmaceutical Journal* 1944 and printed with slight alterations

Name of Preparation	Description	Makers
	Vitamin A	
Alphalin	Capsules 10 000 I U per capsule	Lilly
Avoleum	Liquid 30 000 I U per gm Capsules *4500 I U* per capsule	B D H
β Carotene	Crystals 1 600 000 I U per gm	Napp
Carotene Oil	(1) 0 785 mg α and 1 54 mg β carotene representing 3195 I U A per gm (2) 0 1 mg α and 0 068 mg β carotene representing 1210 I U A per gm	Napp
Carotene Tabloid	2 mg per tabloid	B W
Davitamon A	6000 I U and 60 000 I U per mil ampoules 60 000 I U in 1 mil oil solution	Organon
Essogen	2000 I U per capsule	Lever
Fish Liver Oil	*Liquid 200 000 I U per gm*	*Napp*
Prepalin	Liquid 72 000 I U per mil Capsules 24 000 I U per capsule Ampoules 100 000 I U in 1 mil	Glaxo
Vitamin A	Capsules 33 000 I U per capsule Ampoules 100 000 I U in 1 mil	Crool [illegible]
Vitapex Pabyrn	Capsules 4500 I U per capsule Ampoules 75 000 I U per mil	Paines & Byrne
	Vitamin B_1 (Aneurine)	
Befortiss	Ampoules 5 mg 10 mg and 25 mg	Vitamins Ltd
Benerva	Tablets 1 mg and 3 mg per tablet *Ampoules 5 mg per ampoule* Ampoules Forte 25 mg per ampoule	Roche Products
Berin	Ampoules 5 and 25 mg per ampoule Tablets 1 mg and 3 mg per tablet	Glaxo
Betaxan	Tablets 1 mg and 3 mg per tablet Ampoules 5 mg and 25 mg per mil Solution 250 mg in 10 mils Elixir 0 675 mg per drachm	Bayer
Betalin 1 Capsules	*Capsules 125 I U per capsule*	Lilly
Betalin [illegible]	Ampoules 1 mg 6 mg 10 mg and 30 mg per ampoule Tablets 0 1 mg 3 mg and 6 mg per tablet	Lilly

Name of Preparation	Description	Makers
Betelnon	Tablets 1 mg per tablet Ampoules 2 mg in 1 mil Ampoules Strong 10 mg in 1 mil	Merck
Cryto Vibex	Ampoules 5 mg and 25 mg per mil Solution 50 mg per mil Tablets 1 mg and 3 mg per tablet	P D & Co
Davitamon B_1	Tablets 1 mg per tablet Ampoules 5 mg Forte Tablets 3 mg per tablet Ampoules 25 mg	Organon Organon
Pulvis Vitamin B_1	(1) B P standard (2) Double B P standard	Napp
Ryzamin B	80 I U per gm	B W
Thiamin Chloride	Tablets 1 mg and 3 mg per tablet Elixir 1800 I U per fluid ounce	Abbott Abbott
Vitamin B_1	Ampoules 1 5 mg and 3 mg per ampoule Tablets 1 5 mg and 3 mg per tablet Injection 1 5 and 3 mg	A & H
Vitamin B_1	Ampoules 5 mg and 25 mg per mil Tablets 1 mg and 3 mg per tablet	B D H
Vitamin B_1 Hydrochloride	Hypoloid 5 mg and 25 mg in 1 mil Tabloid 3 mg and 5 mg per tabloid	B W
Vitamin B_1	Ampoules 5 mg and 25 mg per mil Capsules 1 mg per capsule Tablets 1 mg and 3 mg per tablet	Crookes Labs
Vitamin B_1 Pabyrn	Ampoules 5 mg and 25 mg per ampoule Tablets 1 mg and 3 mg per tablet	Paines & Byrne
	Nicotinic Acid	
Davitamon PP Nicotinic Acid	Tablets 50 mg per tablet	Organon
Nicotinic Acid	Tablets 50 mg per tablet	Bayer
Nicotinic Acid	Tablets 50 mg per tablet	P D & Co
Nicotinic Acid	Tablets 50 mg per tablet	A & H
Nicotinic Acid	Tablets 50 mg and 100 mg per tablet	B D H
Nicotinic Acid	Hypoloid 50 mg in 1 mil Tabloid 50 mg per tabloid	B W

Name of Preparation	Description	Makers
Nicotinic Acid	Ampoules 50 mg per 2 mil ampoule Tablets 50 mg per tablet	Crookes Labs
Nicotinic Acid	Tablets 20 mg 50 mg and 100 mg per tablet	Lilly
Nicotinic Acid	Tablets 50 mg per tablet	Roche
Nicotinic Acid	Tablets 25 mg per tablet	Squibb
Pelonin (Nicotinic Acid)	Ampoules 50 mg per 2 mils Tablets, 50 mg per tablet	Glaxo
Nicotinamide	*Ampoules 50 mg Tablets 50 mg* per tablet	B D H
Nicotinamide	Tablets 50 mg per tablet Ampoules 50 mg per ampoule	Roche
	Vitamin B_2 (Riboflavine)	
Lactoflavine	Ampoules 1 mg and 5 mg per ampoule Tablets 1 mg and 3 mg per tablet	Roche Products
Riboflavine	Ampoules 1 mg in 2 mils Tablets, 1 mg	B D H
Riboflavine	*Hypoloid 1 mg per 2 mil* Tabloid 1 mg and 5 mg per tabloid	B W
Riboflavine	Tablets 1 mg = 400 Sherman Units (G) per tablet	Lilly
Riboflavine B_2	Tablets 1 mg per tablet Ampoules *1 mg*	Crookes Labs
	Vitamins B_1 and B_2 (Aneurine and Riboflavine)	
Benerva *Compound*	Tablets 1 mg B_1 1 mg riboflavine (B_2) 15 mg nicotinamide	Roche
Betalin Compound	Capsules 333 I U B_1 40 Sherman units B_2 and other factors of B_2 complex per capsule	Lilly
B & G Capsules	Capsules *67 I U B_1 and 0 01 mg B_2 riboflavine per capsule*	Squibb
B & G Syrup	50 I U B_1 and 0 01 mg B_2 riboflavine per mil	Squibb

Name of Preparation	Description	Makers
Marmite	30 I U B_1 0 033 mg B_2 and 0 61 mg nicotinic acid per gm	Marmite Food Ex tract Co
Vitamin B Capsules	160 I U B_1 and 40 Sherman units B_2—(0 1 mg) riboflavine per capsule	Abbott
Marmite	(Unstandardized) B_1 8–10 I U per gm (approx) B_2 0 033 mg per gm (approx) Nicotinic acid 0 61 mg per gm (approx)	Marmite Food Co
Vitamin B_1 Complex	(1) 100 I U B_1 and 0 1 mg B_2 per gm (2) 200 I U B_1 and 0 2 mg B_2 per gm	Napp
Yeast (Brewers)	Tablets 15 I U B_1 and 20 Sherman units B_2—(0 05 mg) riboflavine per tablet	Abbott
	Vitamin B_6 (Pyridoxin)	
Vitamin B_6 (Pyridoxin)	Ampoules 50 mg per 1 ml Tab lets 10 mg per tablet	Crookes Labs
Pyridoxin	Ampoules 50 mg per ampoule Tablets 10 mg per tablet	B D H
Pyridoxin	Ampoules 50 mg per ampoule Tablets 10 mg per tablet	Vitamins Ltd
	Vitamin C (Ascorbic Acid) 10 mg = 200 I U	
Ascorbic Acid Tablets	*50 mg per tablet*	*Abbott*
Ascorbic Acid	Ampoules 100 mg and 500 mg per ampoule Tablets 5 mg 25 mg and 50 mg per tablet	A & H
Ascorbic Acid	Tablets 25 mg and 50 mg per tablet Tablets 5 mg (Vitamin C for infants) per tablet Am poules 100 mg and 500 mg per ampoule	B D H
Ascorbic Acid	Tabloid 5 mg 25 mg and 50 mg per tabloid	B W
Ascorbic Acid	Tablets 50 mg per tablet	Vitamins Ltd
Cantan	Tablets 5 mg 25 mg and 50 mg per tablet Ampoules 100 mg and 500 mg	Bayer

Name of Preparation	Description	Makers
Celin	Ampoules 100 mg per 1 mil Tablets 5 mg and 50 mg per tablet	Glaxo
Cevalin	5 mg and 25 mg per tablet	Lilly
Davitamon C	Tablets 5 mg and 25 mg per tablet Ampoules 50 mg and 500 mg	Organon
Planavit C	Tablets 5 mg and 50 mg per tablet	May & Baker
Redoxon	Tablets 5 mg 25 mg and 50 mg per tablet Ampoules 100 mg and 500 mg	Roche Products
Vitamin C	Ampoules 100 mg Tablets 5 mg and 50 mg	Crookes Labs
Vitamin C (Pabyrn)	Ampoules 100 mg and 500 mg Tablets, 5 mg 25 mg and 50 mg per tablet	Paines & Byrne
Vitamin C	Ampoules 500 mg Tablets 25 mg and 50 mg per tablet	P D & Co
	Concentrate 43 mg per gramme	Napp
	Black currant syrup 70 mg in 1 dr	
	Rose hip syrup 200 mg in 1 dr	
	Vitamin D	
Calciferol	Tabloid 0 1 mg (4000 I U) and 0 25 mg (10 000 I U) per *tabloid* Wellcome solution 3000 I U per gm	B W
Calcium with Vitamin D	250 I U per teaspoonful Capsules 250 I U per 3 min capsule Ampoules 5000 I U per 1 mil	Crookes Labs
Calcydic	1500 I U per drm Tablets 500 I U per tablet with dicalcium phosphate	A & H
Calfo Rayol	Tablets 660 I U with 8 grains dicalcium phosphate and 6 grains calcium gluconate	Squibb
Calsimil	Tablets containing calcium sodium lactate 5 gr with Vitamin D_2 500 I U	B D H
Calsolact D Tablets	Tablets calcium sodium lactate with 1000 I U of D per tablet	A & H
Colloidal Calcium with Ostelin' (Vitamin D)	Injection 5000 I U per mil	Glaxo
Davitamon D	Liquid 5000 I U per mil in oil solution	Organon

Name of Preparation	Description	Makers
Davitamon D Forte	Liquid 12 500 I U per ml Ampoules 12 500 I U per ml	Organon
Davitamon D Superforte	Liquid 300 000 I U per ml Ampoules 300 000 I U per ml	Organon
Decufer	Tablets 500 I U with iron copper and manganese	Organon
Ostelin	Liquid 5000 I U per ml	Glaxo
	Tablets 500 I U and 50 000 I U per tablet Emulsion 100 I U per 3 fl oz	Glaxo
Ostocalcium	Tablets 500 I U per tablet	Glaxo
Radiostol	Solution 3000 I U 100 000 I U and 200 000 I U per gm Pellets 3000 I U per pellet	B D H
Viosterol	Liquid 15 000 I U per gm	A & H
Vitamin D (Labyrn)	Ampoules 15 000 I U per ml Tablets 2000 I U per tablet	Paines & Byrne

Vitamins A and D

Name of Preparation	Description	Makers
Adexolin	Liquid 12 000 I U A 2000 I U D per ml Capsules 4 500 I U A 900 I U D per capsule	Glaxo
Advita	2000 I U A 200 I U D per capsule	Lever Bros
Bynol	Liquid 300 I U A 40 I U D per gm	A & H
Cod Liver Oil Ointment	2500 I U A 250 I U D per gm	A & H
Cod Liver Oil Perfected	Not less than 1200 I U A 150–200 I U D per gm	A & H
Cod Liver Oil Reinforced	2000 I U A 500 I U D per ml	May & Baker
Crookes Emulsion	2000 I U A 200 I U D per dr	Crookes Labs
Davitamon A D	Liquid 6000 I U A 5000 I U D per ml Capsules 3000 I U A 2000 I U D per capsule	Organon
Davitamon A D Comfits	Comfits 1500 I U A 1000 I U D per comfit	Organon
Dekadexolin	Ampoules 60 000 I U A 10 000 I U D per ml	Glaxo
Halibol	Liquid 40 000 I U A 6500 I U D per gm Capsules 4500 I U A 900 I U D per capsule	A & H

Name of Preparation	Description	Makers
Halibol Calcium Capsules	4500 I U A 900 I U D and 5 gr calcium sodium lactate per capsule	A & H
Halibut Liver Oil Natural	Liquid 40 000 I U A 3000 I U D per gm Capsules 4500 I U A 450 I U D per capsule	A & H
Halibut Liver Oil	(1) Liquid 30 000 I U A 2000 I U D per gm (2) From 20 000 to 100 000 I U A from 2 000 to 3000 I U D per gm	Napp
Halibut Liver Oil	Liquid 5200 I U A 2500 I U D per gm Capsules 425 I U A 8800 I U D per capsule	Crookes Labs
Halidexol	Liquid 5740 I U A, 382 I U D per dr	Crookes Labs
Haliver Oil	Capsules 4500 I U A 450 I U D per capsule Liquid 50 000 I U A 850 I U D per gm	Abbott
Haliverol	Liquid 27 000 I U A 5400 I U D per gm Capsules 4500 I U A 900 I U D per capsule	P D & Co
Hepicoleum	Capsules 4500 I U A 1000 I U D per capsule	Lilly
Halycalcyne	Capsules 5330 I U A 1063 I U D per capsule with calcium phosphate	Crookes Labs
Minadex Syrup	600 I U A 100 I U D per ml	Glaxo
Nadola	Liquid 27 000 I U A 2700 I U D per gm Capsules 4500 I U A 450 I U D per capsule	P D & Co
Navitol	Liquid 55 000 I U A 10 000 I U D per gm Capsules 9400 I U A 1700 I U D per capsule	Squibb
Oladol	Liquid 55 000 I U A 5500 I U D per gm Capsules 6000 I U A 600 I U D per capsule	Abbott
Radiostoleum	Ampoules 75 000 I U A 15 000 I U D Liquid 15 000 I U A 3000 I U D per gm Capsules 4500 I U A 900 I U D per capsule	B D H
Rayolex	Tablets 3300 I U A, 660 I U D per tablet	Squibb

Name of Preparation	Description	Makers
Seven Seas High Potency Oil	2400 I U A 340 I U D per gm	British C L O Producers
Super D Oil	Liquid 6,700 I U A 52 000 I U D_2 per gm Capsules 11 000 I U A 9000 I U D_2 per capsule	Crookes Labs
Vitamin A and D	Capsules 4,000 I U A 1000 I U D per capsule	Vitamins Ltd
Vitapan	Capsules 4,000 I U A 1000 I U D per capsule Compound tablets 1500 I U A and 300 I U D with 1/40 grain parathyroid and calcium glycerophosphate	Paines & Byrne
	Vitamin E	
Davitamon E	Capsules 0 5 ml wheat germ oil per capsule	Organon
Ephynal	Tablets 3 mg (*Racemic tocopheryl acetate*) and 20 mg per tablet (3 I U per tablet)	Roche Products
Fertilol	Wheat germ oil 5 minims per capsule	Vitamins Ltd.
Phytoferol	Capsules equivalent 3 mg dl α tocopherol per capsule	B D H
Trigol	Capsules 5 minims of wheat-germ oil	Abbott
Vitamin E	Capsules 3 mg α tocopherol per capsule	A & H
Vitamin E	Tabloid, 3 mg tocopherol per tabloid	B W
Vitamin E Germinol (Pabyrn)	Capsules each equivalent to 5 gm wheat germ oil	Paines & Byrne
Viteolin	Capsules [illegible] mg of α tocopherol per 3 minim capsule	Glaxo
Wheat Germ Oil	1/3 mg per 3 min capsule	Crookes Labs
Wheat Germ Oil	[illegible] Evans Burr U per gm	Lilly
	Vitamin K	
Davitamon K	Liquid 10 mg acetomenaphthone per ml oil solution Tablets 10 mg per tablet Ampoules 10 mg menaphthone per ml oil solution	Organon

Name of Preparation	Description	Makers
Kappaxan	Tablets 10 mg acetomenaphthone per tablet Ampoules 8 mg menaphthone	Bayer
Kaykisyn	4 Amino 2 methyl 1 naphthol, 1 mg in 1 mil	P D & Co
Klotogen	Liquid 1250 units (Almquist method) equivalent to 46 500 Dam units per mil Capsules, 1000 units (Almquist method) equivalent to approx 37 500 Dam units	Abbott
Menaphthone	Tabloid 2 mg per 'tabloid Hypoloid' ampoules 5 mg in 1 mil	B W
Prokayvit	Ampoules 5 mg menaphthone per mil Tablets 10 mg acetomenaphthone per tablet Solution 10 mg capsules in oil solution	B D H
Synkavit	Tablets 10 mg (tetra sodium salt of 2 methyl 1 4 naphthahydroquinone diphosphate) water soluble vitamin K analogue Ampoules 10 mg	Roche
Vitamin K	Capsules 1/3 mg methylnaphthaquinone Ampoules 5 mg in 1 mil	Crookes Labs
Vitamin K	Ampoules 10 mg menaphthone per mil Tablets 10 mg acetomenaphthone	Paines & Byrne
	Vitamin P	
Vitamin P	*Ampoules 10 mg hesperidin per 1 ml*	Crookes Labs
Permidin	Tablets 150 mg	Glaxo
	Combinations	
Abecedin	Tablets 4500 I U A 50 I U B_1 B_2 equal to 2 5 gm fresh brewer s yeast 200 I U C 600 I U D_2 per tablet Emulsion similar constituents per fl drm excluding B_2	Napp

Name of Preparation	Description	Makers
Abidon	Capsules 4500 I U A 30 I U B_1 10 Sherman units B_2 450 I U D per capsule	P D & Co
Abidon with Vitamin C	Capsules 4500 I U A 30 I U B_1 20 Sherman units B_2 10 mg C per capsule 450 I U D	P D & Co
A B D Capsules	Capsules, 5000 I U A 30 I U B_1 10 Sherman units B_2 500 I U D	Abbott
A B D Capsules	3000 I U A 0 3 mg B_1 per capsule 40 Sherman Bourquin units B_2 200 I U D	A & H
A B D G	Capsules 6600 I U A 33 I U B_1 0 02 mg B_2 (Riboflavine) 1320 I U D per capsule	Squibb
B fortis	0 3 1 0 3 mg B_1 with other factors of B complex	Vitamins Ltd
Beta Cevalin	Capsules 167 I U B_1 12 5 mg C per capsule	Lilly
Crysto Vibex with Vitamin C	Tablets 0 5 mg B_1 12 5 mg C per tablet	P D & Co
Davitamon Five	Tablets 1000 I U A 50 I U B_1 0 5 mg nicotinic acid 10 mg C 200 I U D per tablet	Organon
Halibol B Capsules	Capsules 4500 I U A (B_1 and B_2 equal to 5 grains dried yeast) 900 I U D per capsule	A & H
Halibol Malt	8400 I U A 1100 I U D per oz	A & H
Haliborange	600 I U A 150 I U D 1 mg C per gm	A & H
Halimalt	Liquid 4300 I U A 420 I U D 44 I U B_1 per dr	Crookes Labs
Haliver Malt with Viosterol	28 000 I U A 60 I U B_1 50 Sherman units B_2—(0 125 mg) Riboflavine per fl oz 8000 I U D	Abbott
Halycitrol	Liquid 2600 I U A 315 I U D 2 mg C per dr	Crookes Labs
Homicebrin	3000 I U A 83 I U B_1 200 Sherman units B_2 200 mg C 1000 I U D	Lilly
Medicaps	Capsules 4000 I U A 33 I U B_1 25 mg C 1320 I U D 22 micro gm B_2 vitamin G the whole of the B_2 complex	Savory & Moore

Name of Preparation	Description	Makers
Multivite	Pellets 2500 I U A 160 I U B_1 12 5 mg C 250 I U D_2 per pellet	B D H
Nestrovite	Tablets 2500 I U A 0 5 mg B_1 20 mg C 500 I U D per tablet Emulsion 2500 I U A 0 25 mg B_1 15 mg C 500 I U D per tea spoonful	Roche Pro ducts
Penta Kaps	Capsules 4500 I U A 75 I U B_1 10 mg C 600 I U D 20 Sherman units B_2 per capsule	Abbott
Priovit	1 mg B_1 25 mg C 15 mg nicotin amide	Bayer
Radiostoleum emulsion with vitamin C	1500 I U A 300 I U D 50 I U C per gm	B D H
Vimaltol	16 I U A 2 7–2 9 I U B_1 35 I U D per gm	Wander
Vitamin Tonic Glanules	6200 I U A 100 Sherman Chase units B_1 10 mg C 945 I U D B_2 liver concentrate (1 12) 60 mg per glanule	Armour
Vitamin Quota	Capsule 4500 I U A 100 I U B_1 450 I U D 100 γ B_2 per capsule	Crookes Labs
	Miscellaneous Preparations	
Bemax	280 I U A 320–420 I U B_1 0 9 mg B_2 1 1 mg P P factor 0 45 mg B_6 8 mg E magnesium 09 mg 330 mg phosphorus 2 7 mg iron 0 45 mg copper per oz	Vitamins Ltd
Cofron Capsules	Capsules approx 40 Sherman units B_2—(0 1 mg) approx 5 I U B_1 from liver per capsule with iron and copper	Abbott
Cofron Elixir	Approx 35 I U B_1 approx 180 Sherman units B_2 = 0 45 mg Riboflavine from liver per 3 table spoonfuls with iron and copper	Abbott
Colact	Sweetened milk cocoa with 65 I U D per oz	Glaxo

Name of Preparation	Description	Makers
Complevite	Tablets Vitamin A 4000 I U B_1 0 6 mg C 20 mg D 300 I U calcium 160 mg iron 68 mg iodine manganese copper 3 parts per million	Vitamins Ltd
Decufer Tablets	Tablets 20 mg reduced iron 0 2 mg cupric carbonate 0 2 mg manganese chloride 500 I U D (calciferol)	Organon
GlucoDin	9 I U D per gm	Glaxo
Glucose D T B	250 I U D per oz	A & H
Glucose D	250 I U D per oz	Glaxo
Hebulon	Capsules 25 I U B_1 and liver extract from 16 g fresh liver contains in addition B_2 and B_6 Ferrous sulphate exsiccated 2 gr per capsule	Squibb
Iberin	22 I U B_1 20 Sherman units B (B_2) with iron ammonium citrate and liver concentrate per capsule	Abbott
Irradex	6600 I U A 2200 I U D 75 I U B_1 Iron and ammonium citrate 4 grs manganese citrate soluble ½ gr with malt extract in each fl oz	P D & Co
Ostermilk No 1	200 I U D per reconstituted pint	Glaxo
Ostermilk No 2	165 I U D per reconstituted pint	Glaxo
Ostomalt	220 I U A 50 I U D with malt extract calc glycerophosph and concentrated orange juice	Glaxo
Pregnavite	Tablets Vitamin A 4000 I U B_1 0 6 mg D 300 I U 1 1 mg nicotinamide 25 mg calcium 160 mg iron 68 mg iodine manganese copper 3 parts per million	Vitamins Ltd
Radio Malt	2000 I U A 1000 I U D_2 extract of yeast equivalent to 0 1 oz fresh yeast in each fl oz	B D H
Viozin Ointment	500 I U D per gm	Glaxo